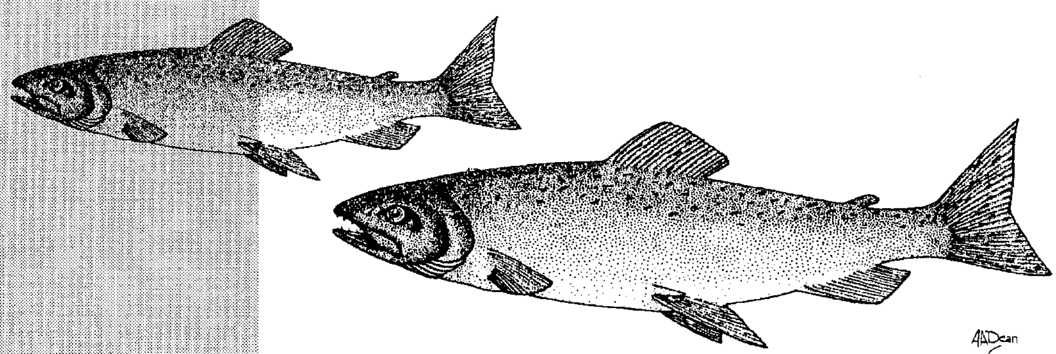
# AN ANALYSIS OF SNAKE RIVER FALL CHINOOK SALMON WITH REGARD TO THE QUESTION OF WHETHER OR NOT AVAILABLE SCIENTIFIC AND COMMERCIAL DATA SUPPORTS RECLASSIFICATION OF THIS ESA LISTED STOCK FROM THREATENED TO ENDANGERED STATUS



Regional Information Report No. 1J95-06


Alaska Department of Fish and Game
Division of Commercial Fisheries Management and Development
Douglas, Alaska



February 1995

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**PREFACE**

On August 18, 1994, the National Marine Fisheries Service (NMFS) took emergency action to reclassify Snake River fall chinook salmon from threatened status to endangered status. On December 28, 1994, NMFS announced intent to permanently reclassify Snake River fall chinook salmon from threatened status to endangered status through the Federal Register (59 FR 66784) and requested comments. Staff of the Alaska Department of Fish and Game developed a scientific analysis to determine if the action was justified and based on the best available scientific and commercial data, the standard required for Endangered Species Act listing decisions. The Alaska Department of Fish and Game scientific analysis was forwarded to the National Marine Fisheries Service on February 22, 1995, by Commissioner Frank Rue. This Regional Information Report includes Commissioner Frank Rue's cover letter and the Alaska Department of Fish and Game's scientific analysis.

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## ACKNOWLEDGEMENTS

Various staff of the Alaska Department of Fish and Game (ADF&G) and the Alaska Department of Law (ADL) provided data, analysis, and critical reviews of this report. Jim Blick (ADF&G) developed the dilution model and "genetic pool" estimates. Michael R. Dean (ADF&G) contacted various biologists in the "lower 48" and assisted in obtaining data used in the report. James E. Seeb (ADF&G) contacted geneticists and obtained their interpretation of the introgression of hatchery strays on the Snake River fall chinook salmon ESU. Jay W. Nelson (ADF&G) and Henry Wilson (ADL) critically reviewed the report.

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February 22, 1995

Mr. William W. Stelle, Jr.
Northwest Regional Director
National Marine Fisheries Service
7600 Sand Point Way N.E.
Bin C15700 Building 1
Seattle, WA 98115

Dear Mr. Stelle:

This letter is written in response to your February 12 invitation to concerned parties to comment on *Federal Register* Notice, 59 FR 66784, December 28, 1994, announcing the National Marine Fishery Services's determination to reclassify listed Snake River chinook salmon from threatened to endangered. Alaska's primary interest in this action is with the Snake River fall chinook salmon stock. Actions taken by the National Marine Fishery Service (NMFS) relative to Snake River fall chinook salmon have the potential to greatly affect our Southeast Alaska salmon fishery where this stock is harvested at a very low rate. Past actions taken by the NMFS due to concern over this stock have had significant effects on the Southeast Alaska economy and life style, and we are concerned about future NMFS actions, as these actions may also affect future jobs and families in Alaska. Our interest is in ensuring that any decision regarding the reclassification of Snake River fall chinook follows sound biological principles and be rigorously justified using the best available scientific and commercial data.

Fishery scientists of the Alaska Department of Fish and Game have reviewed the information included in the notice, gathered additional information, and developed an analysis of the NMFS intended action. The report developed by these fishery scientists is attached to this letter.

Our analysis led to two conclusions. First, the best available scientific and commercial data indicates that the change of Snake River fall chinook from threatened status to endangered status is not appropriate because the status of the currently defined ESU has improved since listing and the likelihood of extinction has diminished considerably. And second, the Snake River fall chinook ESU itself needs redefinition to include Lyons Ferry hatchery fish.

Thank you for the opportunity to provide comments on this proposed federal action.

Sincerely,

Kevin Brooks

for Frank Rue
Commissioner



11-K2LH

**AN ANALYSIS OF SNAKE RIVER FALL CHINOOK SALMON WITH REGARD TO THE QUESTION OF WHETHER OR NOT AVAILABLE SCIENTIFIC AND COMMERCIAL DATA SUPPORTS RECLASSIFICATION OF THIS ESA LISTED STOCK FROM THREATENED TO ENDANGERED STATUS**

## BACKGROUND

Chinook salmon *Oncorhynchus tshawytscha* are native to the Columbia River and its largest tributary, the Snake River. Three runs of chinook salmon are recognized in the Snake River based upon entry time of adults into fresh water (spring, summer, and fall).

Historically, the Snake River supported the largest run of fall chinook in the Columbia Basin. Fall chinook were widely distributed throughout the Snake River and many of its tributaries. Fall chinook spawned and reared from the confluence of the Snake and Columbia rivers upstream some 615 miles to Shoshone Falls, Idaho. The most important spawning grounds (Evermann 1896) were from river mile 328 (near Huntington, Idaho) to river mile 607 (near Auger Falls, Idaho).

Fall chinook were prevented from migrating above river mile 456 in 1901 because of the construction of Swan Falls Dam (Parkhurst 1950). An average of about 72,000 fall chinook annually returned to the Snake River between 1928 and 1949 (Irving and Bjornn 1981). Annual abundance of Snake River fall chinook subsequently declined to an average of about 29,000 fish during the 1950s (Irving and Bjornn 1981), but none the less, the Snake River remained the most important production area for fall chinook in the Columbia River basin (Fulton 1968). The construction of Brownlee Dam at river mile 285 in 1958, Oxbow Dam at river mile 273 in 1961, and Hells Canyon Dam at river mile 247 in 1967 blocked upstream passage of Snake River fall chinook and thus prevented the stock from reaching what had before been the major spawning and rearing areas (Van Hyning 1968).

Snake River fall chinook spawning and rearing habitat was further reduced during the 1960s and 1970s by the construction of four dams in the lower portion of the river even though these dams provided upstream passage devices. The four dams were: (1) Ice Harbor Dam at river mile 10 in 1961; (2) Lower Monumental Dam at river mile 42 in 1969; (3)

Little Goose Dam at river mile 70 in 1970; and, (4) Lower Granite Dam at river mile 108 in 1975. As a result of the extensive hydro-development of the Snake River, the freshwater spawning and rearing habitat available to Snake River fall chinook has been reduced to a small fraction of what was available historically.

The remnant population of Snake River fall chinook remaining today is believed to spawn in the 100 miles of the Snake River between Hells Canyon Dam (river mile 247) and the pool above Lower Granite Dam (river mile 108; pool is 39 miles in length); although deep water spawning in the tail-races of the four lower river dams is believed to occur. Counts of fall chinook at Lower Granite Dam since 1975 (ODFW & WDF 1991 & 1992) when it was constructed have ranged from 780 in 1980 (450 adults and 330 jacks) to 2,585 in 1986 (784 adults and 1,801 jacks). Reproductive potential of the population as measured by adults passing Lower Granite Dam decreased from a level of 1,000 in 1975 to 335 adults in 1990.

On June 7, 1990, NMFS received an Endangered Species Act petition to add Snake River fall chinook salmon to the list of threatened and endangered species from Oregon Trout, with co-petitioners Oregon Natural Resources Council, the Northwest Environmental Defense Center, American Rivers, and the Idaho and Oregon Chapters of the American Fisheries Society. NMFS published a notice on September 11, 1990, announcing that the petition presented substantial scientific information indicating that the listing may be warranted and a status review of fall chinook was initiated. In June 1991, NMFS published a status review for Snake River fall chinook salmon (Waples et al. 1991) and a proposed rule to add Snake River fall chinook to the endangered species list with the status being listed as threatened (June 27, 1991; 56 FR 29547). The following spring, NMFS announced its final decision to list Snake River fall chinook as threatened on the endangered species list (Vol. 57, No. 78, April 22, 1992). On August 18, 1994, NMFS took emergency action to reclassify Snake River fall chinook from threatened to endangered status. This emergency rule expires on April 15, 1995. On December 28, 1994, NMFS announced intent to permanently reclassify Snake River fall chinook as endangered (59 FR 66784) and requested comments. This document was prepared to provide NMFS with comments from the State of Alaska on the permanent reclassification of Snake River fall chinook from threatened to endangered status.

## WHAT IS MEANT BY THREATENED AND ENDANGERED?

The Endangered Species Act defines the terms endangered species and threatened species as follows.

*The term "endangered species" means any species which is in danger of extinction throughout all or a significant portion of its range other than a species of the Class Insecta determined by the Secretary to constitute a pest whose protection under the provisions of this Act would present an overwhelming and overriding risk to man.*

*The term "threatened species" means any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.*

NMFS made an attempt to better define these terms relative to listing decisions concerning salmon through a paper by Thompson (1991). Under the recommendations section, Thompson (1991) states:

*Likewise, the various analytic approaches can provide useful information with a minimum of time and data. As an example of how such approaches can be used, the density-independent diffusion model and estimation procedures described by Dennis et al. (in press) will be considered below in some detail.*

In discussing the Dennis model, Thompson goes on to say:

*Finally, implementation of this or any other model requires choosing p* and t* values. Actually two sets of threshold values are required in the context of ESA, since the Act defines two levels of jeopardy (endangered and threatened). As noted in the Introduction, it is unfortunate that the ESA does not define endangerment with much precision. In the absence of further guidance, perhaps the best decision for "endangered" p* and t* values is to accept the conventional wisdom that sets p* = 0.95 and t* = 100. In other words, at the "endangered" level, MVP is the population size that gives a 95% chance of extinction over the next 100 years.*

*While the ESA is decidedly vague regarding the definition of endangerment, it does give some indication of how "threatened" p* and t* values should relate to their "endangered" counterparts. Since a threatened species is defined as one which is "likely to become endangered within the foreseeable future," one need only interpret the terms "likely" and "foreseeable future" to relate "threatened" MVP to the "endangered" MVP. A reasonable interpretation of a "likely" event would be one which has at least a 50% chance of occurring. Quantifying "foreseeable future" is not so straightforward, but perhaps something like 10 years would be satisfactory. In other words, the "threatened" MVP is the population size that gives a 50% chance of reaching the "endangered" MVP within 10 years.*

This provided a frame of reference for the NMFS initial decisions concerning the status of various salmon stocks including Snake River fall chinook at the time this stock was added as a threatened species to the endangered species list.

## THREATENED VERSUS ENDANGERED STATUS

The basic question is whether status of Snake River fall chinook has changed since Waples et al. (1991) evaluated stock status and NMFS provisionally decided in 1991 to list this stock as a threatened species, a decision that NMFS subsequently reaffirmed with a final listing decision in 1992.

Waples et al. (1991) evaluated a number of factors in considering the level of risk faced by Snake River fall chinook salmon in 1991 and concluded that:

> *the current population occupies a fraction of its former range, the remaining (and historically, the most productive) habitat having been inundated by reservoirs or blocked by dams.*

Waples et al. (1991) concluded that adult returns of Snake River fall chinook declined by three to four orders of magnitude from pristine levels. Waples et al. (1991) specifically recognized that the estimated number of wild spawners in 1987, 1989, and 1990 were the second, fourth, and first lowest on record, respectively; and that in 1990 just 78 wild fish were estimated to have passed Lower Granite Dam, only 31% of the number in the next lowest year (1987).

Waples et al. (1991) evaluated the use of two time series of data for applying the Dennis model to Snake River fall chinook in an effort to determine extinction likelihood, and concluded that a statistically significant change in growth rate parameters of the population occurred for runs that returned following construction and operation of the four lower river dams (about 1980; the first year for which almost all returning adults had to out-migrate through Lower Granite Dam as juveniles). Because a time series used to estimate extinction probabilities that spans a fundamental change in parameters affecting the population can give misleading results, Waples et al. (1991) leaned heavily on the 1980-1990 estimates of "natural" fall chinook crossing Lower Granite Dam and concluded based upon application of the Dennis model to this data set that the probability of extinction within 100 years was 10.8%. This probability of extinction (based upon recent population trends) was less than the 95% probability of extinction level suggested by

Thompson (1991) as a minimum viable population threshold for endangered status. However, other considerations and the higher probability of extinction associated with using a longer time trend in a second Dennis model led NMFS staff to conclude that a threatened listing decision was in order. Waples et al. (1991) concluded their stock status report with the following statement:

> *In light of the above factors, and further considering that a) drought conditions have likely adversely affected juvenile survival in several recent years, reducing the prospects for recovery in the near future as these year classes return as adults and b) there is clear evidence that stray hatchery fish of non-Snake River origin pose a serious threat to the genetic integrity of the wild population, the BRT concluded that Snake River fall chinook salmon face a substantial risk of extinction if present conditions continue.*

Following the Waples et al. (1991) paper and a proposed rule by NMFS to add Snake River fall chinook to the endangered species list with the status being defined as threatened (June 27, 1991; 56 FR 29547), various reviewers to the proposed rule stated that fall chinook should be listed as endangered rather than threatened. On April 22, 1992, NMFS responded to this very pointed criticism in the final rule and specifically stated:

> *The threatened species designation in the proposed rule was based on an assessment of the best available scientific and commercial information, taking account of efforts to protect the species. In making its final determination, NMFS considered the 1991 estimated escapement of 318 wild adult fall chinook salmon above Lower Granite Dam. This represents a considerable increase over the 1990 estimated escapement of 78 adults. Further, starting in 1991, all hatchery-produced fall chinook from the Snake and Umatilla Rivers were tagged in order to separate adult hatchery and wild fish at Snake River dams. Tagged hatchery fish will be prevented from ascending further upstream, while wild fish will be allowed to proceed. This measure will be significant in reducing any introgression of the Snake River gene pool with Columbia and Snake River hatchery-produced fall chinook salmon. Furthermore, at Lyons Ferry Fish Hatchery, the practice of taking wild fish for brood stock has been stopped. Despite the need for caution in using the most recent years figure in determining a trend, this increase approaching previous escapement levels typical of the 1980s may be attributable, at least in part, to the protective measures already undertaken. Consequently, NMFS is issuing a final determination to list the Snake River fall chinook salmon as threatened under the ESA.*

A very notable change in the NMFS approach to Snake River fall chinook and the listing status determination question is apparent in the two 1994 Federal Registers (emergency status change rule dated August 18, 1994, and the proposed permanent reclassification dated December 28, 1994). Rather than relying upon a reasoned, objective analysis of available scientific and commercial data as in the previous administrative record, NMFS changed its approach and is now relying predominantly upon: (1) pre-season projections of the 1994 return of fall chinook to the mouth of the Columbia River; (2) guesses relative to the 1995 return; and (3) a new characterization of wild escapements that have accrued since listing as being "low." Specifically, the December 28, 1994, Federal Register states:

> *After the listing of Snake River fall chinook salmon as a threatened species in 1992, adult counts at Lower Granite Dam during 1992 and 1993 remained at low levels. In-season estimates for the 1994 return indicate that the situation has not substantially improved. This lack of overall improvement during recent years, exacerbated by the low returns of 1994 and expected low returns in the next few years, indicates that the Snake River fall chinook salmon faces an imminent threat of extinction throughout all or a significant portion of its range. The projected adult return of listed Snake River fall chinook salmon to the Columbia River during 1994 is 803 fish, the second lowest on record (Columbia River Technical Staffs (CRTS) 1994). As discussed in CRTS (1994) and summarized in NMFS (1994), the number of listed Snake River fall chinook returning in 1994 is expected to be below replacement level (i.e., fewer progeny than parents); spawners have not replaced themselves in 7 or 8 of the last 9 years.*
>
> *Although final count data from the 1994 return will not be available until February 1995, a tentative forecast of the 1995 run size suggests that the return will be about 60% of that expected in 1994 (NMFS and USFWS 1994). While it is impossible to make specific projections for returns of fall chinook over the next 3 to 5 years, it is possible to comment generally on the prospects for decreasing run sizes. The number of offspring from the 1991 brood is apparently quite small based on the record low return of jacks in 1993. Therefore, the 5 year-old component of the 1996 return is likely to be low. There was sufficient escapement in 1992 and 1993 to allow for increased returns after 1995, but success of these runs will depend largely on improvements in migration passage and ocean survival conditions.*
>
> *Although risks associated with small population sizes are also applicable to Snake River fall chinook salmon,*

*currently there is no evidence of multiple, naturally spawning subpopulations of this species. Still, the primary risk to Snake River fall chinook salmon remains the continued low numbers of spawning adults, and genetic and demographic risks will increase if the population remains at depressed levels for a number of consecutive years.*

Thus while in 1992, NMFS describes the count of 318 wild fall chinook over Lower Granite Dam as representing "*a considerable increase over the 1990 estimated escapement of 78 adults*," in 1994, NMFS describes counts of 549 and 742 wild fall chinook over Lower Granite Dam in 1992 and 1993, respectively as escapements that "*remained at low levels.*"

The estimated wild escapement past Lower Granite Dam in 1990 was 78 fish, the lowest on record since 1980 when as Waples et al. (1991) documented, a statistically significant change in growth rate parameters of the population occurred. Since 1990, wild escapement past Lower Granite Dam has been estimated at 318, 549, 742, and 441 fish which represent the twelfth highest, third highest, first highest, and sixth highest escapements, respectively, of wild Snake River fall chinook during this 15 year period. The average escapement of fall chinook salmon past Lower Granite Dam from 1980 through 1990 was 377 fish; while the average for 1991 through 1994 was 512 fish, a 36% increase. The facts are that the estimated number of wild fall chinook passing above Lower Granite Dam has increased by a factor of about one third over the levels that escaped prior to listing and since the change in growth rate parameters to this population occurred as a direct result of loss of habitat and increase in migration difficulty due to dam construction.

Additionally, the escapement of wild fall chinook above Lower Granite Dam in 1994 was not the second lowest on record as the pre-season 1994 forecast indicated (and as the December 28, 1994 Federal Register uses as best available scientific data), but was instead ranked number 11 of 20 since 1975 (when Lower Granite Dam was installed), and ranked number 6 of 15 since 1980 (the first year for which the majority of the adults had to circumvent all four lower river dams during their juvenile downstream migration). Given the currently restricted spawning and rearing habitat, the 1994 escapement of wild fall chinook was within the range of escapements expected; it hardly approached a record low level as stated in the December 28, 1994 Federal Register.

Further, the record low count in 1993 of 39 jacks which was used as a rational in the December 28, 1994, Federal Register to predict a low run of adults in 1994 and a continued low run of adults in 1995, hardly resulted in a dismal return of adults in 1994. In fact the second lowest count of jacks passing Lower Granite Dam (102 jacks) occurred in 1992 and was followed one year later with an adult return of 742 fish (the highest count since 1980; rank 1 of 15) and an adult return two years later of 441 fish (the sixth highest count since 1980; rank 6 of 15).

Thus, the basic question as to whether status of Snake River fall chinook has changed since 1990 and whether or not this change justifies a change in the listing status has not been adequately substantiated by the information presented in the December 28, 1994, Federal Register. NMFS in announcing its decision to reclassify Snake River fall chinook from threatened to endangered failed to use the best available scientific and commercial data. Further, NMFS has substantially changed their characterization of the value of escapement increases since 1990 in an arbitrary and capricious manner. To properly address the change in listing status question, an objective analysis is required.

## INFORMATION NEEDED TO DETERMINE THE NEED FOR A CHANGE IN THE LISTING OF SNAKE RIVER FALL CHINOOK

Several analyses necessary to make a biologically sound determination concerning the need to reclassify the Snake River fall chinook from threatened to endangered were absent from the December 28, 1994 Federal Register announcement. The following factors should be analyzed prior to any change in the listing of the Snake River fall chinook.

### Escapement

An objective analysis should include the basic data concerning escapements of fall chinook through 1994. The basic data presented should include estimates of both "natural" fish and strays in the escapements. And to the extent possible, hatchery production should be separated from "natural" production so that trends in the "natural" population can be more fully evaluated. Because of the way the evolutionarily significant unit (ESU) is currently defined, the key question is whether or not "natural" escapements have increased over levels prior to listing. A change in status to the more conservative endangered level of ESA listing would be in order if natural escapements decreased relative to pre-listing levels.

### Likelihood of Extinction

An objective analysis should compare the status and risk of extinction for fall chinook through 1990 to the status and risk of extinction for fall chinook through 1994. Determination of the likelihood of extinction based upon time series ending in 1990 versus time series ending in 1994 will indicate whether the likelihood of extinction has:

(1) decreased, indicating a change in status is not warranted;
(2) stayed the same, indicating a change in status is probably not warranted; or,
(3) increased, indicating a change in status is warranted.

**Probability of Persistence with Respect to Survival**

An objective analysis of the current status of Snake River fall chinook should also consider the new information recently developed in conjunction with the *IDFG v NMFS* litigation settlement negotiations relative to the probability of persistence with respect to survival under recent and various alternative hydro system management configurations. The key question here is whether changes in the management of the hydro system are placing the stock of fall chinook in more jeopardy (indicating a change in status may be warranted) or are placing the stock in less jeopardy (indicating a change in status is not warranted).

**Spawner-Recruit Relationship**

An objective analysis should include investigation of the effects of spawner density on recruitment of Snake River fall chinook. A spawner-recruit relationship developed for escapements past Lower Granite Dam is needed to assist in quantifying the level of escapement appropriate for this stock under present conditions. Prior analyses have concluded that escapements should increase above recent levels, but an objective analysis is generally lacking relative to how much increase is appropriate given the diminished availability of habitat for Snake River fall chinook since 1975.

This spawner-recruit relationship should be limited to escapements enumerated since 1975 since the progeny of these escapements had to negotiate all four of the lower river dams and these spawners and their recruits had to reside in the reduced freshwater spawning and rearing habitats available following construction of all major Snake River dams. This relationship (a Ricker function) has the potential to be far more informative than the spawner to spawner relationship developed by Dygert (1994) and Roler (1994) because it will help to determine if production of fall chinook is dependent upon spawner density as is typically the case for anadromous salmon populations. Further, residuals in the modeled spawner-recruit relationship can be used in conjunction with other variables to better understand the factors currently limiting production of Snake River fall chinook spawning and rearing in the wild.

### Forecasts of Adult Returns

An objective analysis should include evaluation of the accuracy of forecasts to predict future years returns of Snake River fall chinook before these forecasts are used to make listing status changes and before too much faith is placed in these forecasts for other ESA related management actions.

### Hatchery Strays and Genetic Integrity

An objective analysis of the current status of this ESA protected stock should also address the "species" question. In determining if Snake River fall chinook qualify as a species under the ESA, Waples et al. (1991) concluded with the following statement

> *Although the NMFS Northwest Region Biological Review Team (BRT) concluded that, historically, Snake River fall chinook salmon were an ESU, it is not so clear whether this is still the case. One viewpoint is that introgression from Columbia River hatchery strays has caused the Snake River population to lose the qualities that made it "distinct" for ESA purposes. Evidence in support of this viewpoint includes genetic and tagging data documenting effects of straying on Lyons Ferry Hatchery brood stock, estimates that in 1990 a high proportion of fish passing Lower Granite Dam and found on nearby spawning grounds were hatchery strays, and the lack of any positive information documenting the continued existence of "pure" wild fish. However, given that 1) an ESU was present until at least the early 1980s, 2) substantial straying of upper Columbia River hatchery fish has occurred only within the last generation, and 3) no direct evidence exists for genetic change to wild fall chinook salmon in the Snake River, the BRT felt it would be premature to conclude that the ESU no longer exists.*

Since 1990, four years of additional data are available concerning strays past Lower Granite Dam and the question of whether or not this stock of salmon still meets the NMFS standard of a "species" from an ESA standpoint should be addressed in the status review. Further, the historic stock of Snake River fall chinook is currently represented by two groups of fish:

(a) fish associated with Lyons Ferry Hatchery, fish not presently protected under the ESA because they are not classified as being in the Snake River fall chinook salmon ESU by NMFS; and

(b) progeny of fish spawning in the wild in the Snake River, fish which are protected under the ESA because they are the fish defined by NMFS to be in the Snake River fall chinook salmon ESU.

Fish readily cross between the ESA protected portion of the population and the ESA unprotected portion of the population across generations due to brood stock collections and straying. Up-to-date genetic information concerning introgression of Columbia River strays on the "natural" population should be summarized, analyzed, and presented. Models should be developed of the likely "genetic pool" of fish defined as "naturals" based upon various assumptions concerning the fitness of Snake River strays and Columbia River strays as they enter the spawning grounds used by the "naturals". Key questions and points that need to be addressed by a change in status review of the Snake River fall chinook salmon ESU include:

Is it logical to have both a protected and an unprotected portion of the remnant endemic stock of Snake River fall chinook?

Is it logical to have put into place a system of ESA mandated protection where members of the population move into and out of the ESU across generations and hence move in and out of the protected class?

Is it logical to apply ESA mandated protection to the portion of the stock that likely least resembles the historic endemic stock?

Should the ESU be modified and redefined to include Lyons Ferry Hatchery fish? And if so, is this modified ESU threatened or endangered?

Does the protected portion of the stock (or as an alternative, both portions of the stock) still meet the species standard or has introgression resulted in a hybrid stock that no longer meets the ESU criteria for ESA protection?

Should the appropriate ESU be Snake River-Upper Columbia River fall chinook? And, if so, is this potential ESU threatened or endangered?

## BASIC ESCAPEMENT DATA

The longest continuous set of complete data concerning abundance of Snake River fall chinook are the counts of these fish as they passed over Ice Harbor Dam; counts are available from 1965 through 1994 (Table 1; Figure 1). Counts of adult fall chinook over Ice Harbor Dam decreased ten-fold from levels of about 10,300 per year from 1965-1974 to levels of about 1,300 per year from 1975-1979. These reductions reflect the stock reduction associated with construction of the full set of lower river dams. Counts for the period 1980 through 1990 (pre-listing and post dam construction effects) averaged about 2,800, about double the counts during the 1975-1979 period. During this period (1980-1990), an egg bank program for Snake River fall chinook eventually led to the release of fall chinook at Lyons Ferry Hatchery, and resulted in the counts at Ice Harbor Dam reflecting not only the escapement of naturally spawning fish upstream of this dam but the returns to the upstream hatchery as well. Counts of Snake River fall chinook passing Ice Harbor Dam during the period 1991 through 1994 averaged about 3,500; about three-fold the average counts during the period 1975-1979 and about 25% above the levels counted during the 1980-1990 period. Counts of fall chinook passing Ice Harbor Dam during the period 1991-1994 also represent a combined assessment of both natural spawners and returns to the Lyons Ferry Hatchery.

Part of the brood stock development program for the Snake River egg bank and the continued development of brood stock for Lyons Ferry Hatchery involved taking fish ("mining") immediately upstream of the counting station at Ice Harbor Dam (Table 2; Figure 2). Between 1976 and 1990, from 162 to 1,613 of the Snake River adult returns were "mined" for brood stock. This resulted in the abundance of natural spawners being depressed by annual levels that ranged from 7% to 53% as the run progressed upstream (Table 1; Figures 3, 4, and 5). "Mining" was confined to known hatchery fish from 1991-1993; in 1994, no fish were "mined" at this downstream location.

Counts of fall chinook passing Lower Granite Dam have been made since 1975 (Table 3). Total counts of fall chinook passing Lower Granite Dam since 1975 have ranged from 575 fish in 1990 (385 adults and 190 jacks) to 2,585 fish in 1986 (784 adults and 1,801 jacks). Abundance of adults during the 1975-1979 period averaged about 640 fish; abundance of adults from 1980-1990 averaged about 620 fish; and, abundance of adults from 1991-1994 averaged about 860 fish or almost 40% higher than the earlier periods before Snake River fall chinook were added to the endangered species list as a threatened species.

Coded wire tag technology provided a tool during the early 1980s to identify individual stocks of salmonids. Use of this tool since 1983 in the Snake River has provided estimates of the number of chinook counted past Lower

Table 1. Proportion of chinook passing Little Goose and Ice Harbor Dams used for Lyons Ferry brood stock and adjustments to natural escapements over Lower Granite Dam (located upstream) due to the brood stock "mining", 1965-1994.

| Year | Adult Fall Chinook Counted Over Ice Harbor Dam and Removed for Brood Stock: Counted | Removed | % Removed | % Passage Allowed Past lower Dams | Brood Stock Adjust. Factor | Adult Fall Chinook Natural Escapements Past Lower Granite Dam: Unadjusted | Adjusted |
|---|---|---|---|---|---|---|---|
| 1965 | 8,200 | 0 | 0 | 100% | 1.00 | NA | NA |
| 1966 | 12,800 | 0 | 0 | 100% | 1.00 | NA | NA |
| 1967 | 14,000 | 0 | 0 | 100% | 1.00 | NA | NA |
| 1968 | 19,500 | 0 | 0 | 100% | 1.00 | NA | NA |
| 1969 | 13,600 | 0 | 0 | 100% | 1.00 | NA | NA |
| 1970 | 9,000 | 0 | 0 | 100% | 1.00 | NA | NA |
| 1971 | 9,300 | 0 | 0 | 100% | 1.00 | NA | NA |
| 1972 | 7,500 | 0 | 0 | 100% | 1.00 | NA | NA |
| 1973 | 6,700 | 0 | 0 | 100% | 1.00 | NA | NA |
| 1974 | 2,400 | 0 | 0 | 100% | 1.00 | NA | NA |
| 1975 | 1,900 | 0 | 0 | 100% | 1.00 | 1,000 | 1,000 |
| 1976 | 1,100 | 0 | 38%[1] | 62% | 1.61 | 470 | 757 |
| 1977 | 1,200 | 395 | 33% | 67% | 1.49 | 600 | 894 |
| 1978 | 1,100 | 368 | 33% | 67% | 1.49 | 640 | 954 |
| 1979 | 1,200 | 439 | 37% | 63% | 1.59 | 500 | 795 |
| 1980 | 1,200 | 394 | 33% | 67% | 1.49 | 450 | 671 |
| 1981 | 770 | 407 | 53% | 47% | 2.13 | 340 | 724 |
| 1982 | 1,600 | 473 | 30% | 70% | 1.43 | 720 | 1,030 |
| 1983 | 1,800 | 619 | 34% | 66% | 1.52 | 428 | 651 |
| 1984 | 1,700 | 663 | 39% | 61% | 1.64 | 324 | 531 |
| 1985 | 2,046 | 589 | 29% | 71% | 1.41 | 438 | 618 |
| 1986 | 3,104 | 212 | 7% | 93% | 1.08 | 449 | 485 |
| 1987 | 6,788 | 1,613 | 24% | 76% | 1.36 | 253 | 344 |
| 1988 | 3,847 | 1,076 | 28% | 72% | 1.39 | 368 | 512 |
| 1989 | 4,634 | 1,179 | 25% | 75% | 1.33 | 295 | 392 |
| 1990 | 3,470 | 1,092 | 31% | 69% | 1.45 | 78 | 113 |
| 1991 | 4,500 | 361[2] | 0 | 100% | 1.00 | 318 | 318 |
| 1992 | 4,636 | 256[2] | 0 | 100% | 1.00 | 549 | 549 |
| 1993 | 2,805 | 129[2] | 0 | 100% | 1.00 | 742 | 742 |
| 1994 | 2,087 | 0 | 0 | 100% | 1.00 | 441 | 441 |

[1] Brood stock removal in 1976 took place at Little Goose Dam rather than Ice Harbor Dam; 430 adults counted, 162 removed (38%).

[2] Removal of fall chinook for Lyons Ferry brood stock from 1991 through 1994 has been selective; only fish with missing adipose fins (coded wire tagged) have been removed; and hence, there has been no effect on upstream passage rate of "natural" fish spawning above Lower Granite Dam.

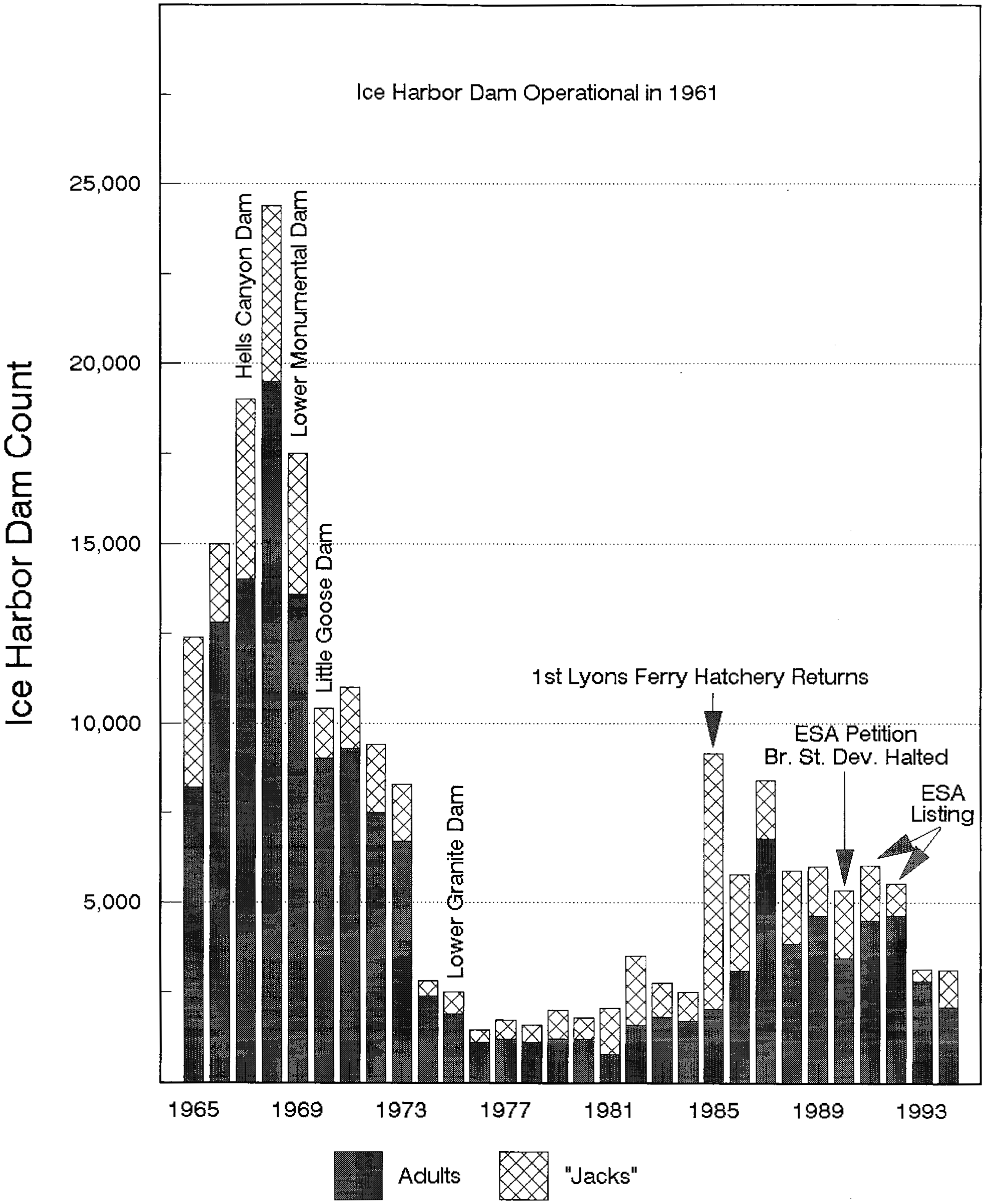



Figure 1. Number of fall chinook counted past Ice Harbor Dam since 1965, the year in which the major Snake River dams became operational, and years associated with ESA and hatchery events.

Table 2. Number of fall chinook associated with the Snake River egg bank program from 1975-1983 and with the Lyons Ferry Hatchery from 1984-1994.[1]

| Year | Lyons Ferry Hatchery Volunteers | | Kalama Falls Hatchery | | Collected at Ice Harbor Dam | | Collected at Lower Granite Dam | | Total Brood Stock | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Adults | Jacks | Adults | Jacks | Adults | Jacks | Adults | Jacks | Adults | Jacks |
| 1975 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1976 | 0 | 0 | 0 | 0 | 162[2] | ? | 0 | 0 | 162 | ? |
| 1977 | 0 | 0 | 0 | 0 | 395 | ? | 0 | 0 | 395 | ? |
| 1978 | 0 | 0 | 0 | 0 | 368 | ? | 0 | 0 | 368 | ? |
| 1979 | 0 | 0 | 0 | 0 | 439 | ? | 0 | 0 | 439 | ? |
| 1980 | 0 | 0 | 208 | ? | 394 | ? | 0 | 0 | 602 | ? |
| 1981 | 0 | 0 | 561 | ? | 407 | ? | 0 | 0 | 968 | ? |
| 1982 | 0 | 0 | 98 | ? | 473 | ? | 0 | 0 | 571 | ? |
| 1983 | 0 | 0 | 86 | ? | 619 | ? | 0 | 0 | 705 | ? |
| 1984 | 0 | 0 | 220 | 10 | 663 | 97 | 0 | 0 | 883 | 107 |
| 1985 | 6 | 4,070 | 952 | 0 | 589 | 90 | 0 | 0 | 1,547 | 4,160 |
| 1986 | 245 | 1,125 | 576 | 0 | 212 | 23 | 0 | 0 | 1,033 | 1,147 |
| 1987 | 1,654 | 543 | 0 | 0 | 1,613 | 47 | 0 | 0 | 3,267 | 590 |
| 1988 | 327 | 1,053 | 0 | 0 | 1,076 | 6 | 0 | 0 | 1,403 | 1,059 |
| 1989 | 704 | 670 | 0 | 0 | 1,179 | 0 | 0 | 0 | 1,883 | 670 |
| 1990 | 521 | 602 | 0 | 0 | 1,092 | 0 | 49 | 0 | 1,662 | 602 |
| 1991 | 863 | 675 | 0 | 0 | 361 | 71 | 37 | 0 | 1,261 | 746 |
| 1992 | 898 | 176 | 0 | 0 | 256 | 71 | 178 | 26 | 1,332 | 273 |
| 1993 | 714 | 157 | 0 | 0 | 129 | 0 | 118 | 4 | 961 | 161 |
| 1994[3] | 475 | 507 | 0 | 0 | 0 | 0 | 187 | 141 | 662 | 648 |

NOTE: Since 1990, brood stock used at Lyons Ferry Hatchery have been screened (CWTs examined) and those found not to be of Snake River origin have been shipped to the Klickitat Hatchery in an effort to protect the genetic integrity of the Lyons Ferry brood stock. The estimated portion of Columbia River strays entering the Lyons Ferry brood stock was 4%, 18%, 39%, and 25% in 1987, 1988, 1989, and 1990, respectively (Waples et al 1991). All juvenile progeny from adults spawned in 1989 were marked prior to release and returns from this year class are being prevented from entering the brood stock in future years. Thus the entry of Columbia River strays into the Lyons Ferry brood stock have been effectively prevented from the 1989 brood year forward.

1 Source: Waples et al (1991) and Mundy (1994).

2 Collected at Little Goose Dam (Waples et al 1991).

3 Source for 1994 data: Larrie LaVoy (personal communication).

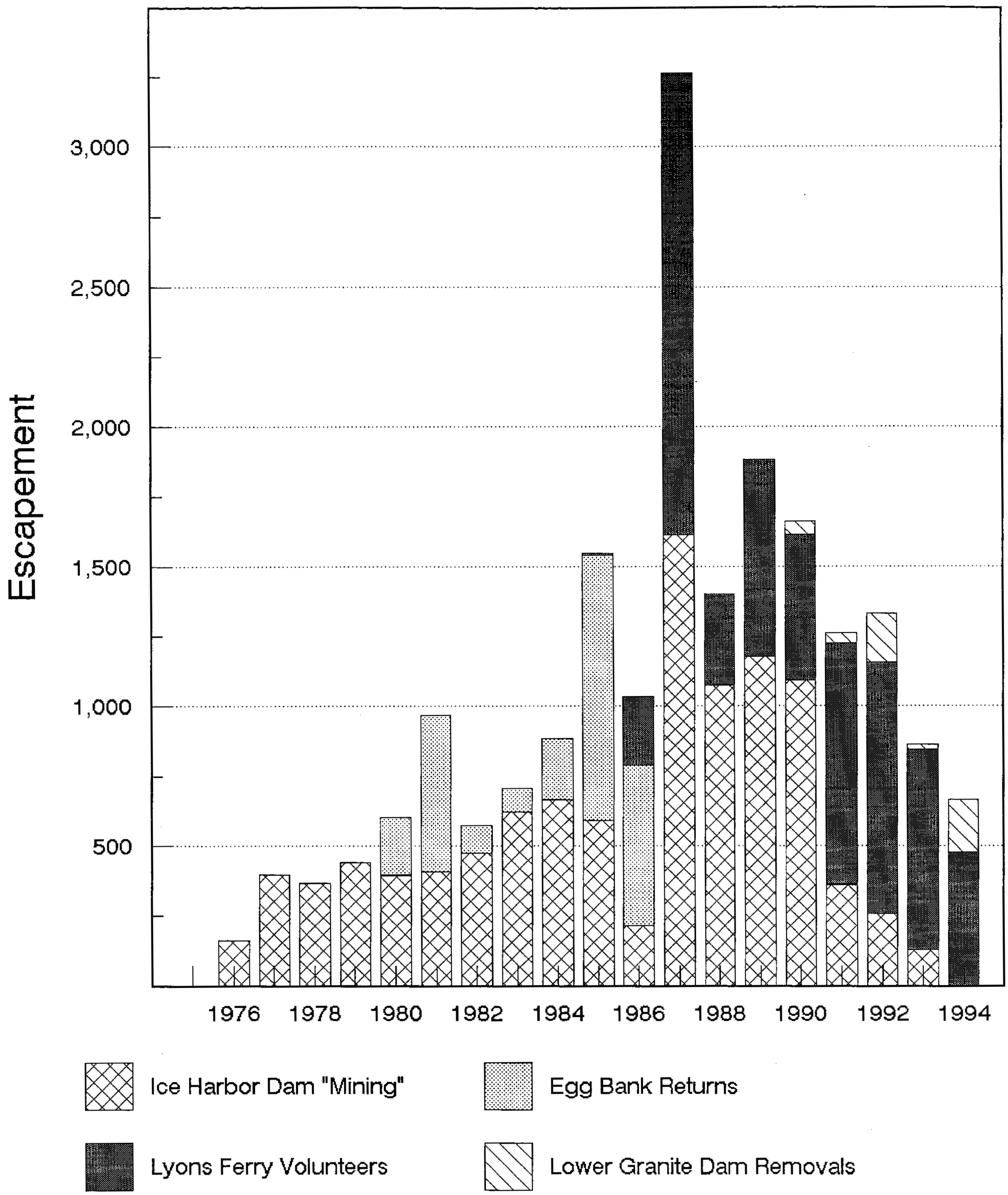



Figure 2. Number of adult Snake River fall chinook associated with the egg bank program from 1975-1983 and with the Lyons Ferry hatchery from 1984-1994.

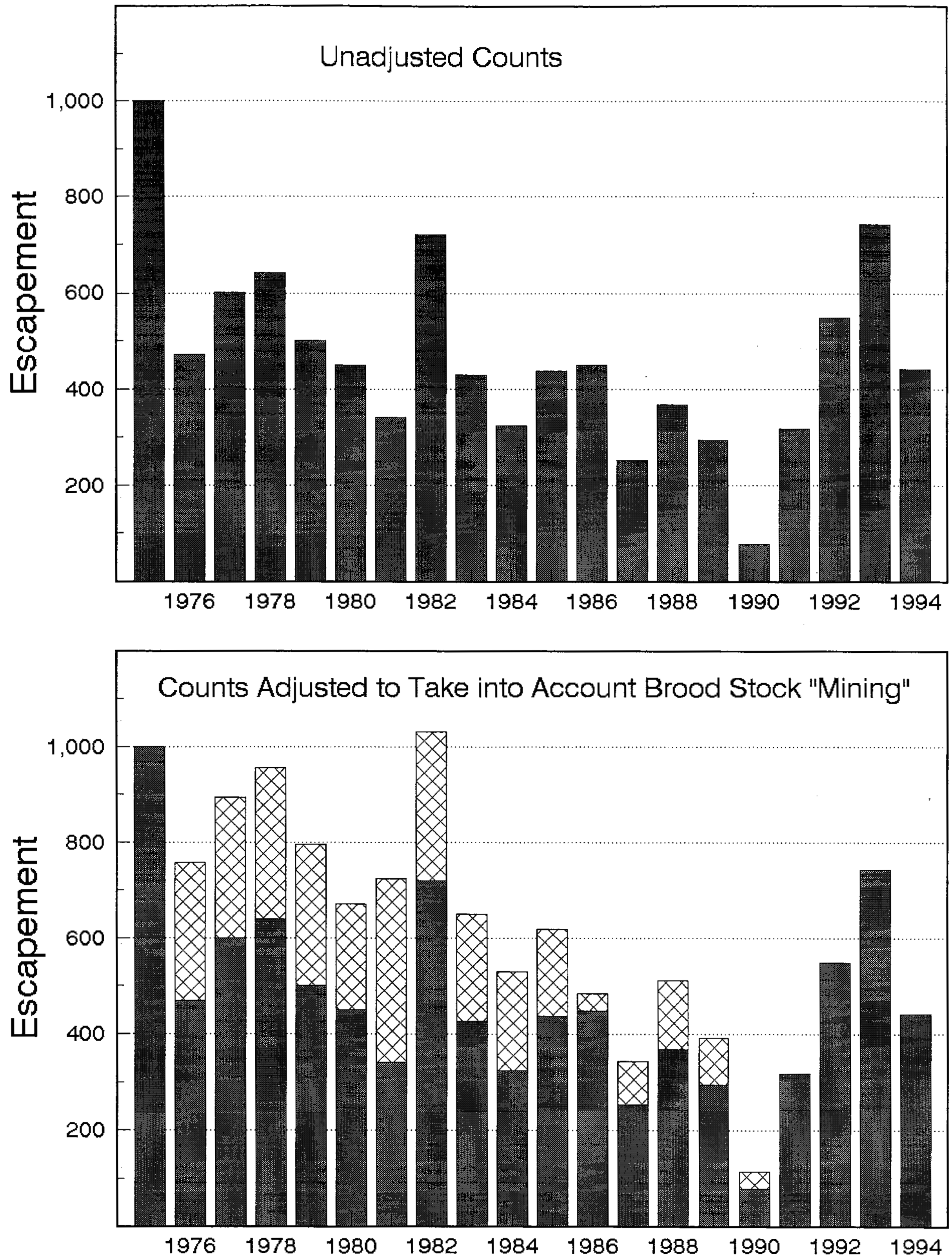



Figure 3. Estimated number of "natural" fall chinook passing Lower Granite Dam based on unadjusted (upper) and adjusted counts (lower).

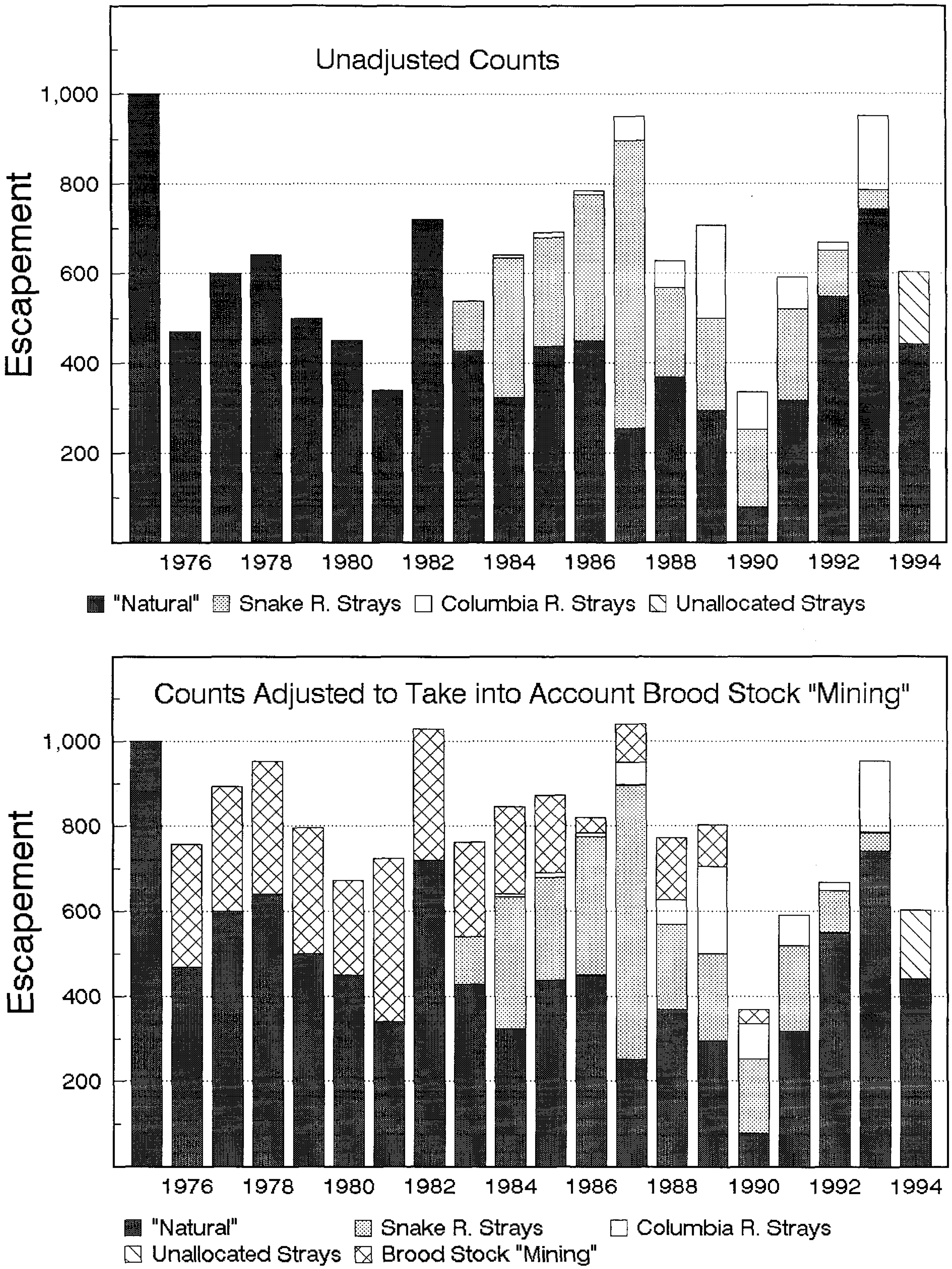



Figure 4. Estimated number of "natural" and stray fall chinook passing Lower Granite Dam; unadjusted (upper) and adjusted (lower).

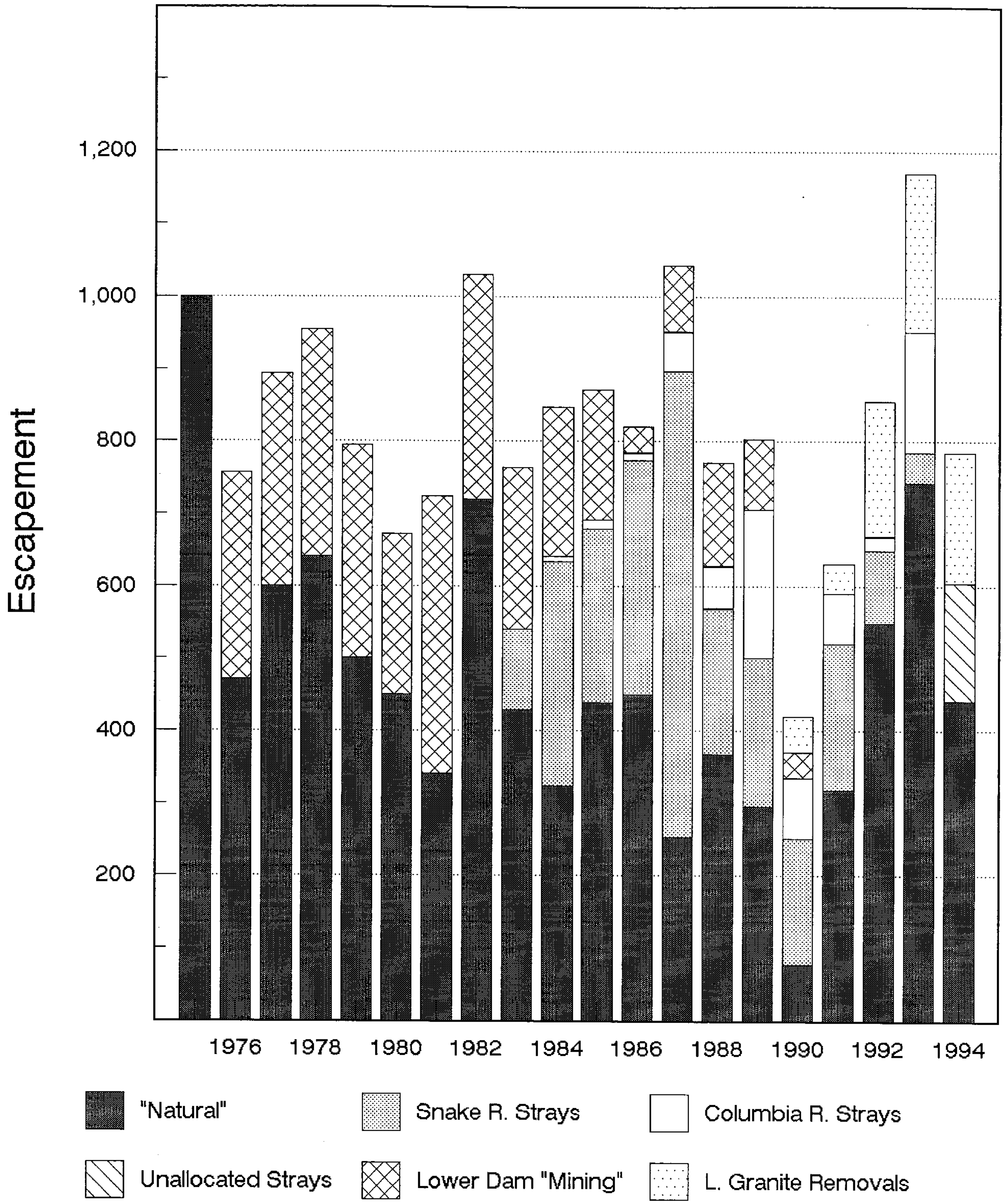



Figure 5. Estimated number of "natural" and stray fall chinook passing Lower Granite Dam adjusted for brood stock "mining" and Lower Granite Dam "removals".

Table 3. Estimated number of fall chinook passing Lower Granite Dam, 1975-1994.

| | | Lyons | | Columbia | Total | Lower Granite Dam Counts | | |
|---|---|---|---|---|---|---|---|---|
| | Natural[1] | Ferry[1] | Hagerman[1] | River[2] | Adult | Adult[3] | Jack[3] | Total |
| Year | Escapement | Strays | Strays | Strays | Escapement | Count | Count | Count |
| 1975 | 1,000[4] | 0 | 0 | 0 | 1,000 | 1,000 | 1,200 | 2,200 |
| 1976 | 470[4] | 0 | 0 | 0 | 470 | 470 | 830 | 1,300 |
| 1977 | 600[4] | 0 | 0 | 0 | 600 | 600 | 1,300 | 1,900 |
| 1978 | 640[4] | 0 | 0 | 0 | 640 | 640 | 850 | 1,490 |
| 1979 | 500[4] | 0 | 0 | 0 | 500 | 500 | 940 | 1,440 |
| 1980 | 450[4] | 0 | 0 | 0 | 450 | 450 | 330 | 780 |
| 1981 | 340[4] | 0 | 0 | 0 | 340 | 340 | 1,400 | 1,740 |
| 1982 | 720[4] | 0 | 0 | 0 | 720 | 720 | 1,500 | 2,220 |
| 1983 | 428 | 0 | 112 | 0 | 540 | 540 | 980 | 1,520 |
| 1984 | 324 | 0 | 310 | 6 | 640 | 640 | 730 | 1,370 |
| 1985 | 438 | 0 | 241 | 12 | 691 | 691 | 1,500 | 2,191 |
| 1986 | 449 | 64 | 261 | 10 | 784 | 784 | 1,801 | 2,585 |
| 1987 | 253 | 575 | 69 | 54 | 951 | 951 | 385 | 1,336 |
| 1988 | 368 | 192 | 9 | 58 | 627 | 627 | 329 | 956 |
| 1989 | 295 | 206 | 0 | 205 | 706 | 706 | 276 | 982 |
| 1990 | 78 | 174 | 0 | 83 | 335 | 385 | 190 | 575 |
| 1991 | 318 | 202 | 0 | 70 | 590 | 630 | 397 | 1,027 |
| 1992 | 549 | 100 | 0 | 19 | 668 | 855 | 102 | 957 |
| 1993 | 742 | 43 | 0 | 167 | 952 | 1,170 | 39 | 1,209 |
| 1994[5] | 441 | ?[6] | 0 | 162[6] | 603 | 785 | 249 | 1,034 |

[1] Source: Dygert (1994); note: these estimates assume no straying of non-hatchery fish and are not adjusted for hatchery straying prior to 1983. All juveniles released from Lyons Ferry Hatchery have been marked with CWTs during the past few years and all returns in 1994 have CWTs.

[2] Source: Waples et al (1991) and Dygert (1994); strays from Umatilla, Priest Rapids, and Yakima (and perhaps other hatcheries) are included in this category. The majority of the Columbia River strays have been from Umatilla releases; all juveniles released into the Umatilla have been marked with CWTs during the past few years and all returns of this stock in 1994 have CWTs. The Umatilla releases have occurred since 1983; poor acclimation of juveniles prior to release and lack of sufficient water for spawning contribute to increased straying of these hatchery fish. The brood source for Umatilla releases are fall chinook migrating over Bonneville Dam after August, the same time frame that Snake River fall chinook migrate past this structure.

[3] Source: ODFW & WDF (1991 & 1994).

[4] Hatchery strays may have passed Lower Granite Dam prior to 1983, but there is no basis for estimating numbers due to lack of hatchery fish being coded wire tagged prior to this time; source: Waples et al (1991).

[5] Source for all 1994 data: Mike Matylewich (personal communication).

[6] Total hatchery strays over Lower Granite Dam in 1994 estimated to be 162 fish; the number of Lyons Ferry versus Columbia River strays unknown at this time.

Granite Dam that were hatchery strays (Tables 3 and 4). Subtraction of the number of strays from the total count of fall chinook at Lower Granite Dam has allowed estimation of the numbers and proportions of the escapements that were the progeny of "natural" spawning (non-hatchery spawned fish). Abundance of non-hatchery spawned adult chinook passing upstream of Lower Granite Dam during the eight-year period 1983-1990 is estimated to average about 330 fish; whereas, abundance of these fish since ESA listing (1991-1994) is estimated to average about 510 fish or about 55% higher than the pre-listing average.

The effect of downstream brood stock "mining" on the estimates of "natural" spawners passing Lower Granite Dam can be made based upon simple proportions (Table 1). "Natural" escapements, adjusted for downstream brood stock "mining" since 1983, essentially removes the effects of the egg bank program and the Lyons Ferry Hatchery from the Lower Granite Dam count. Abundance of non-hatchery spawned adult chinook passing upstream of Lower Granite Dam during the eight-year period 1983-1990 after adjustment for brood stock "mining" is estimated to average 456 fish; whereas, abundance of these fish since ESA listing (1991-1994) is estimated to average 512 fish, an increase of about 12% over the pre-listing average. This 12% increase reflects the change in abundance of "natural" spawners before and after ESA listing without the confusing effects of the egg bank and hatchery program. **Thus, the escapement data, both with and without adjustment for the confusing affects of the egg bank and hatchery program, do not support changing the status of Snake River fall chinook from threatened to endangered.**

A summary of the total Snake River fall chinook population whether they were spawned in the wild or spawned in a hatchery is provided in Tables 5 and 6 and in Figure 6.

## LIKELIHOOD OF EXTINCTION

The probability that Snake River fall chinook salmon would become extinct was estimated to be 10.8% by Waples et al. (1991) using an exponential diffusion model (Dennis et al. 1991). This estimate was made using natural escapements from 1980 to 1990 above Lower Granite Dam and employed a five-year averaging routine. Since that report, no one has been able to duplicate those results (see Cramer and Neeley 1993); and, many of the assumptions behind the analysis and the analytical technique itself may be suspect. In addition, there are four additional years of recent escapements which should help better assess the trend in escapements and project future stock abundances.

Table 4. Proportion of fall chinook passing upstream of Lower Granite Dam that have been documented to have been Snake River and Columbia River strays and that are presumed to have entered the spawning population, 1983-1994.[1]

| Year | Adult Natural Escapement Number | Adult Natural Escapement Percent | Adult Snake River Strays Number | Adult Snake River Strays Percent | Adult Columbia River Strays Number | Adult Columbia River Strays Percent | Total Escapement Number | Total Escapement Percent |
|---|---|---|---|---|---|---|---|---|
| 1983 | 428 | 79% | 112 | 21% | 0 | 0% | 540 | 100% |
| 1984 | 324 | 51% | 310 | 48% | 6 | 1% | 640 | 100% |
| 1985 | 438 | 63% | 241 | 35% | 12 | 2% | 691 | 100% |
| 1986 | 449 | 57% | 325 | 42% | 10 | 1% | 784 | 100% |
| 1987 | 253 | 27% | 644 | 67% | 54 | 6% | 951 | 100% |
| 1988 | 368 | 59% | 201 | 32% | 58 | 9% | 627 | 100% |
| 1989 | 295 | 42% | 206 | 29% | 205 | 29% | 706 | 100% |
| 1990 | 78 | 23% | 174 | 52% | 83 | 25% | 335 | 100% |
| 1991 | 318 | 54% | 202 | 34% | 70 | 12% | 590 | 100% |
| 1992 | 549 | 82% | 100 | 15% | 19 | 3% | 668 | 100% |
| 1993 | 742 | 78% | 43 | 4% | 167 | 18% | 952 | 100% |
| 1994 | 441 | 73% | 162[2] | 27% (max) | 162[2] | 27% (max) | 603 | 100% |

NOTE: Interpretation of this information is complex and the effect of straying is cumulative and dependent upon fitness of strays. If fitness of strays is equal to fitness of natural spawners, then the proportion of the gene pool composed of natural spawning fish in the first year of the series (62%) is further decreased by each of the following years by the added proportion of additional strays into the spawning population in subsequent years. Thus, unless fitness of strays is an extremely low value (close to zero), the composition of the gene pool of the fish called "natural spawners" at the current time is primarily composed of progeny of strays, not progeny of "natural spawners".

[1] Hatchery fish likely strayed above Lower Granite Dam prior to 1983; however, no estimates of this potential straying are available because coded wire tag technology used to document this phenomena was not available nor used on potentially straying hatchery populations of fall chinook prior to this time.

[2] The 1994 estimate of strays entering the escapement past Lower Granite Dam has not yet been split into the Snake and Columbia River components.

Table 5. Estimated number of fall chinook passing Lower Granite Dam and used for Lyons Ferry Hatchery brood stock, 1975-1994.

| Year | Fall Chinook Allowed Past Lower Granite Dam | | | Egg Bank Program/ Brood Stock Used at Lyons Ferry Hatchery | | | Totals | | |
|---|---|---|---|---|---|---|---|---|---|
| | Adults | Jacks | Total | Adults | Jacks | Total | Adults | Jacks | Total |
| 1975 | 1,000 | 1,200 | 2,200 | 0 | 0 | 0 | 1,000 | 1,200 | 2,200 |
| 1976 | 470 | 830 | 1,300 | 162 | ? | ? | 632 | | |
| 1977 | 600 | 1,300 | 1,900 | 395 | ? | ? | 995 | | |
| 1978 | 640 | 850 | 1,490 | 368 | ? | ? | 1,008 | | |
| 1979 | 500 | 940 | 1,440 | 439 | ? | ? | 939 | | |
| 1980 | 450 | 330 | 780 | 602 | ? | ? | 1,052 | | |
| 1981 | 340 | 1,400 | 1,740 | 968 | ? | ? | 1,308 | | |
| 1982 | 720 | 1,500 | 2,220 | 571 | ? | ? | 1,291 | | |
| 1983 | 540 | 980 | 1,520 | 705 | ? | ? | 1,245 | | |
| 1984 | 640 | 730 | 1,370 | 863 | 107 | 970 | 1,503 | 837 | 2,340 |
| 1985 | 691 | 1,500 | 2,191 | 1,547 | 4,160 | 5,707 | 2,238 | 5,660 | 7,898 |
| 1986 | 784 | 1,801 | 2,585 | 1,033 | 1,147 | 2,180 | 1,817 | 2,948 | 4,765 |
| 1987 | 951 | 385 | 1,336 | 3,267 | 590 | 3,857 | 4,218 | 975 | 5,193 |
| 1988 | 627 | 329 | 956 | 1,403 | 1,059 | 2,462 | 2,030 | 1,388 | 3,418 |
| 1989 | 706 | 276 | 982 | 1,883 | 670 | 2,553 | 2,589 | 946 | 3,535 |
| 1990 | 335 | 190 | 525 | 1,662 | 602 | 2,264 | 1,997 | 792 | 2,789 |
| 1991 | 590 | ? | ? | 1,261 | 746 | 2,007 | 1,851 | ? | ? |
| 1992 | 668 | ? | ? | 1,332 | 273 | 1,605 | 2,000 | ? | ? |
| 1993 | 952 | ? | ? | 961 | 161 | 1,122 | 1,913 | ? | ? |
| 1994 | 603 | ? | ? | 662 | 648 | 1,310 | 1,265 | ? | ? |

Table 6. Numbers of fall chinook that were progeny of fish spawning in the wild that passed above Lower Granite Dam in their attempt to return to the upstream spawning grounds adjusted to account for the Lyons Ferry brood stock "mining" program at downstream dams added to the number of fish that were progeny of fish spawned at hatcheries which were prevented from migrating past Lower Granite Dam and returning to the upstream spawning grounds added to the number of fish that were progeny of fish spawned at hatcheries which were allowed to migrate past Lower Granite Dam in their attempt to return the upstream spawning grounds.[1]

| | Progeny of Fish Spawned in the Wild and Allowed Past Lower Granite Dam | | | Progeny of Hatchery Spawned Fish | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | Lower Granite Dam | Fish Allowed Past Lower Granite Dam | | | |
| Year | Natural Escapement | Adjustment | Adjusted Estimate | Trap Removals | Snake River Strays | Columbia River Strays | Total | Grand Total |
| 1975 | 1,000 | 0 | 1,000 | 0 | 0 | 0 | 0 | 1,000 |
| 1976 | 470 | +287[2] | 757 | 0 | 0 | 0 | 0 | 757 |
| 1977 | 600 | +294 | 894 | 0 | 0 | 0 | 0 | 894 |
| 1978 | 640 | +314 | 954 | 0 | 0 | 0 | 0 | 954 |
| 1979 | 500 | +295 | 795 | 0 | 0 | 0 | 0 | 795 |
| 1980 | 450 | +221 | 671 | 0 | 0 | 0 | 0 | 671 |
| 1981 | 340 | +384 | 724 | 0 | 0 | 0 | 0 | 724 |
| 1982 | 720 | +310 | 1,030 | 0 | 0 | 0 | 0 | 1,030 |
| 1983 | 428 | +223 | 651 | 0 | 112 | 0 | 112 | 763 |
| 1984 | 324 | +207 | 531 | 0 | 310 | 6 | 316 | 847 |
| 1985 | 438 | +180 | 618 | 0 | 241 | 12 | 253 | 871 |
| 1986 | 449 | +36 | 485 | 0 | 325 | 10 | 335 | 820 |
| 1987 | 253 | +91 | 344 | 0 | 644 | 54 | 698 | 1,042 |
| 1988 | 368 | +144 | 512 | 0 | 201 | 58 | 259 | 771 |
| 1989 | 295 | +97 | 392 | 0 | 206 | 205 | 411 | 803 |
| 1990 | 78 | +35 | 113 | 50 | 174 | 83 | 307 | 420 |
| 1991 | 318 | 0 | 318 | 40 | 202 | 70 | 312 | 630 |
| 1992 | 549 | 0 | 549 | 187 | 100 | 19 | 306 | 855 |
| 1993 | 742 | 0 | 742 | 218 | 43 | 167 | 428 | 1,070 |
| 1994 | 441 | 0 | 441 | 182 | 162 max | 162 max | 344 | 785 |

[1] All data included in this table refers to adult fish.
[2] The brood stock "mining" in 1976 took place at Little Goose Dam rather than Ice Harbor Dam.

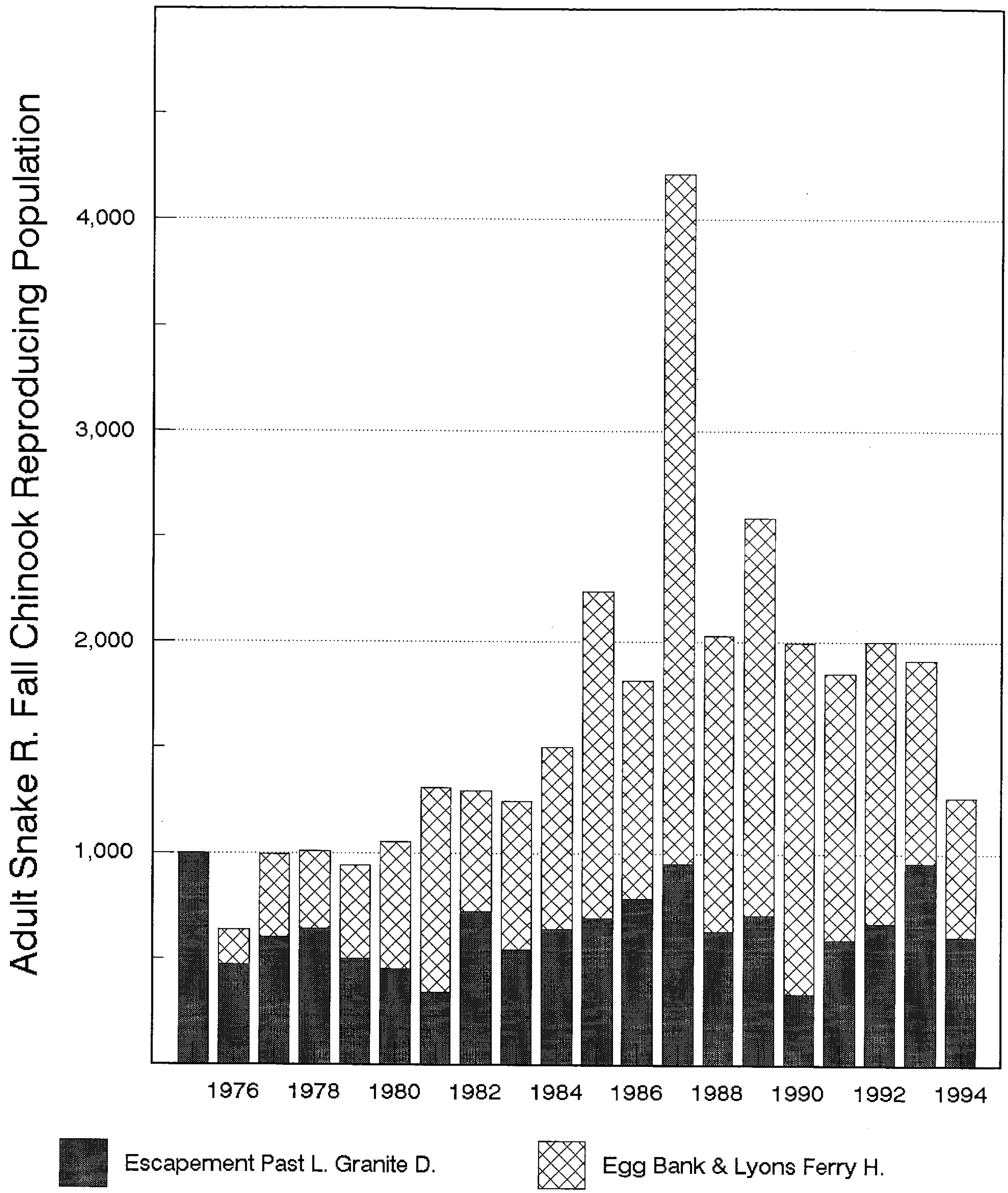



Figure 6. Number of adult fall chinook counted past Lower Granite Dam and the number of adult fall chinook associated with the egg bank program plus Lyons Ferry Hatchery (adult reproducing population).

We developed a more robust method of evaluating trends in escapements and estimating the probability of extinction of Snake River fall chinook within 100 years (by 2089). This method (termed the bootstrap method) employs a bootstrapping technique which randomly selects a ratio of observed escapement by age that has resulted from a given escapement 3, 4, and 5 years before. This method makes no assumption on underlying statistical models, incorporates the age structure of the population into the analysis, and uses a nonparametric error structure. Four time series of data were compared using the bootstrap method:

(1) escapements from 1980-1990;

(2) escapements from 1975-1990;

(3) escapements from 1980-1994; and,

(4) escapements from 1975-1994.

The two time series ending in 1990 represent the information available at the time Snake River fall chinook were first listed. The two time series ending in 1994 represent the information available today and differences in the likelihood of extinction between these ending dates reflect the changes in extinction probability or the change in risk that the listed stock faces. The two time series starting in 1980 reflect the time period when the stock was affected by all Snake River dams during their life cycle; whereas, the time series starting in 1975 reflect a changing period in terms of affects of dams on the listed stock.

A fifth evaluation was conducted using the bootstrap method. The fifth comparison weighted the ratios from parent escapements to 1991-1994 age specific escapements so that these ratios were twice as likely to be randomly chosen as other earlier ratios. This took into account that changes initiated to protect Snake River fall chinook salmon after 1990 would continue and thus ratios calculated using escapements in these years would be more likely to occur than ratios in previous years.

For each simulation in the bootstrap method, the age composition of 1975-1982 and 1994 escapements were randomly selected from the estimated age compositions of the 1983-1993 escapements. The ratios of: (1) escapement in year $i$ to the age 3 escapement in year $i+3$ for the years 1975-1991; (2) escapement in year $i$ to the age 4 escapement in year $i+4$ for the years 1975-1990; and, (3) escapement in year $i$ to the age 5 escapement in year $i+5$ for the years 1975-1989 were calculated to provide the set of ratios to randomly choose from to produce age specific escapements from the parent escapements. Thus production, by age, from a given escapement was randomly selected from historical production ratios.

The escapements used in the bootstrap method are presented in Table 7 and are taken from Dygert (1994) and Matylewich (personal communication) The age compositions of the escapements were taken from Roler (1994). The bootstrap method used 1,000 simulations. Probabilities of achieving specific escapements were estimated as the proportion of times that the 1,000 simulations reached these escapements in the year 2089.

The bootstrap selection process can best be described by illustrating the process with an example (Tables 8 and 9). Table 8 demonstrates how the age compositions are randomly assigned to years that have no age composition data and how production ratios are calculated. The escapement in 1975 is the parent escapement of age 3 fish returning in 1978, age 4 fish in 1979, and age 5 fish in 1980. Since no age composition data is available for 1978, a year with age composition data is randomly chosen (1985) and that age composition is assigned to 1978. Thus 5.4% of the escapement in 1978 (640 fish) is calculated to be comprised of age 3 fish, or 34.6 fish. This results in an estimate of 1,000 fish escapement in 1975 producing 34.6 age 3 fish in 1978, or a parent escapement to age specific return escapement of 0.0346. In a similar manner, the ratio of the 1975 parent escapement to 1979 age 4 return escapement is 0.3610 and the ratio of the 1975 parent escapement to the 1980 age 5 return escapement is 0.1170. This process is continued for parent escapements through 1989 for age 5 returns, 1990 for age 4 returns, and 1991 for age 3 returns. The random selection of age composition for years with unknown age composition is repeated for each of the 1,000 simulations.

Table 9 demonstrates the forecast procedure for one simulation. A parent escapement in 1992 will produce age 3 fish in 1995. Randomly, one of the age 3 parent to age specific return escapement ratios (0.0679) is chosen, which when multiplied by the 1992 escapement, yields an age 3 escapement of 37.3 fish. Likewise, the parent escapement in 1991 of 318 fish, after randomly choosing an age 4 parent to age specific return escapement ratio of 0.8510, will produce 270.6 for the age 4 escapement, and the parent escapement in 1990 of 78 fish, after randomly choosing an age 5 parent to age specific return escapement ratio of 0.1420, will produce 11.1 in the age 5 escapement. This results in a total escapement of 319 fish in 1995. This process is continued through the year 2089 to produce a simulated escapement of 899 fish. If the escapement had decreased to the specified level of extinction (either 1 or 30 fish) the simulation is terminated and the population is considered extinct.

Table 7. Escapement and age composition data used to estimate extinction probabilities for Snake River fall chinook salmon.

| Year | Natural Escapement | Age Composition of Escapement | | |
|---|---|---|---|---|
| | | Three Year Olds | Four Year Olds | Five Year Olds |
| 1975 | 1,000 | | | |
| 1976 | 470 | | | |
| 1977 | 600 | | | |
| 1978 | 640 | 1975 - 1982 age composition estimates not available | | |
| 1979 | 500 | | | |
| 1980 | 450 | | | |
| 1981 | 340 | | | |
| 1982 | 720 | | | |
| 1983 | 428 | 11.4% | 84.6% | 4.0% |
| 1984 | 324 | 8.6% | 91.0% | 0.3 |
| 1985 | 438 | 9.1% | 86.3% | 4.6 |
| 1986 | 449 | 55.9% | 36.1% | 8.0 |
| 1987 | 253 | 8.7% | 89.7% | 1.6 |
| 1988 | 368 | 5.4% | 67.9% | 22.6 |
| 1989 | 295 | 7.8% | 80.7% | 11.5 |
| 1990 | 78 | 12.8% | 75.6% | 11.5 |
| 1991 | 318 | 29.9% | 56.0% | 14.2 |
| 1992 | 549 | 16.8% | 71.6% | 11.7 |
| 1993 | 742 | 6.7% | 85.1% | 8.2 |
| 1994 | 441 | 1994 age composition estimates not available | | |

Data sources: Dygert (1994) for escapements through 1993, Mike Matylewich (personal communication) for escapement in 1994, Roler (1994) for age composition estimates.

Table 8. Example of base period (1975 - 1994) data used to forecast abundances to 2089 and simulation of abundances from 1995 - 2089.

| | | Returns of 3 Yr. Old Escapement | | | | | Returns of 4 Yr. Old Escapement | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Esc. | Year of Return | Percent Age 3 | Total Esc. | Age 3 Esc. | Age 3:Parent Esc. Ratio | Year of Return | Percent Age 4 | Total Esc. | Age 4 Esc. | Age 4:Parent Esc. Ratio | Year of Return | Percent Age 5 | Total Esc. | Age 5 Esc. | Age 5:Parent Esc. Ratio | Notes |
| 1975 | 1,000 | 1978 | 5.4% | 640 | 34.6 | 0.0346 | 1979 | 36.1% | 500 | 180.5 | 0.3610 | 1980 | 11.7% | 450 | 52.7 | 0.1170 | /1 |
| 1976 | 470 | 1979 | 55.9% | 500 | 279.5 | 0.5947 | 1980 | 71.6% | 450 | 322.2 | 0.7160 | 1981 | 1.6% | 340 | 5.4 | 0.0160 | /1 |
| 1977 | 600 | 1980 | 16.8% | 450 | 75.6 | 0.1260 | 1981 | 89.7% | 340 | 305.0 | 0.8970 | 1982 | 11.5% | 720 | 82.8 | 0.1150 | /1 |
| 1978 | 640 | 1981 | 8.7% | 340 | 29.6 | 0.0462 | 1982 | 80.7% | 720 | 581.0 | 0.8070 | 1983 | 4.0% | 428 | 17.1 | 0.0400 | /2 |
| 1979 | 500 | 1982 | 7.8% | 720 | 56.2 | 0.1123 | 1983 | 84.6% | 428 | 362.1 | 0.8460 | 1984 | 0.3% | 324 | 1.0 | 0.0030 | /3 |
| 1980 | 450 | 1983 | 11.4% | 428 | 48.8 | 0.1084 | 1984 | 91.0% | 324 | 294.8 | 0.9100 | 1985 | 4.6% | 438 | 20.1 | 0.0460 | |
| 1981 | 340 | 1984 | 8.6% | 324 | 27.9 | 0.0820 | 1985 | 86.3% | 438 | 378.0 | 0.8630 | 1986 | 8.0% | 449 | 35.9 | 0.0800 | |
| 1982 | 720 | 1985 | 9.1% | 438 | 39.9 | 0.0554 | 1986 | 36.1% | 449 | 162.1 | 0.3610 | 1987 | 1.6% | 253 | 4.0 | 0.0160 | |
| 1983 | 428 | 1986 | 55.9% | 449 | 251.0 | 0.5864 | 1987 | 89.7% | 253 | 226.9 | 0.8970 | 1988 | 22.6% | 368 | 83.2 | 0.2260 | |
| 1984 | 324 | 1987 | 8.7% | 253 | 22.0 | 0.0679 | 1988 | 67.9% | 368 | 249.9 | 0.6790 | 1989 | 11.5% | 295 | 33.9 | 0.1150 | |
| 1985 | 438 | 1988 | 5.4% | 368 | 19.9 | 0.0454 | 1989 | 80.7% | 295 | 238.1 | 0.8070 | 1990 | 11.5% | 78 | 9.0 | 0.1150 | |
| 1986 | 449 | 1989 | 7.8% | 295 | 23.0 | 0.0512 | 1990 | 75.6% | 78 | 59.0 | 0.7560 | 1991 | 14.2% | 318 | 45.2 | 0.1420 | |
| 1987 | 253 | 1990 | 12.8% | 78 | 10.0 | 0.0395 | 1991 | 56.0% | 318 | 178.1 | 0.5600 | 1992 | 11.7% | 549 | 64.2 | 0.1170 | /4 |
| 1988 | 368 | 1991 | 29.9% | 318 | 95.1 | 0.2584 | 1992 | 71.6% | 549 | 393.1 | 0.7160 | 1993 | 8.2% | 742 | 60.8 | 0.0820 | /5 |
| 1989 | 295 | 1992 | 16.8% | 549 | 92.2 | 0.3127 | 1993 | 85.1% | 742 | 631.4 | 0.8510 | 1994 | 11.7% | 441 | 51.6 | 0.1170 | /3 |
| 1990 | 78 | 1993 | 6.7% | 742 | 49.7 | 0.6374 | 1994 | 71.6% | 441 | 315.8 | 0.7160 | | | | | | |
| 1991 | 318 | 1994 | 16.8% | 441 | 74.1 | 0.2330 | | | | | | | | | | | |
| 1992 | 549 | | | | | | | | | | | | | | | | |
| 1993 | 742 | | | | | | | | | | | | | | | | |
| 1994 | 441 | | | | | | | | | | | | | | | | |

/1 Age 3 - 5 Composition Randomly selected from the estimated 1983 - 1993 age composition
/2 Age 3 - 4 Composition Randomly selected from the estimated 1983 - 1993 age composition
/3 Age 3 Composition Randomly selected from the estimated 1983 - 1993 age composition
/4 Age 5 Composition Randomly selected from the estimated 1983 - 1993 age composition
/5 Age 4 Composition Randomly selected from the estimated 1983 - 1993 age composition

Table 9. Example of random selection (bootstrapping) to forecast future escapements.

| | Returns of 3 Yr. Old Escapement | | | Returns of 4 Yr. Old Escapement | | | Returns of 5 Yr. Old Escapement | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Esc. Year | Parent Esc. (Year) | Ratio 3 Yr. Old Esc. | 3 Yr. Old | Parent Esc. (Year) | Ratio 4 Yr. Old Esc. | 4 Yr. Old | Parent Esc. (Year) | Ratio 5 Yr. Old Esc. | 5 Yr. Old | Total Escapement |
| 1995 | 549 (1992) | 0.0679 | 37.3 | 318 (1991) | 0.8510 | 270.6 | 78 (1990) | 0.1420 | 11.1 | 319 |
| 1996 | 742 (1993) | 0.5947 | 441.3 | 549 (1992) | 0.8630 | 473.8 | 318 (1991) | 0.0400 | 12.7 | 928 |
| 1997 | 441 (1994) | 0.1123 | 49.5 | 742 (1993) | 0.7160 | 531.3 | 549 (1992) | 0.1420 | 78.0 | 659 |
| 1998 | 319 (1995) | 0.0395 | 12.6 | 441 (1994) | 0.7560 | 333.4 | 742 (1993) | 0.0460 | 34.1 | 380 |
| 1999 | 928 (1996) | 0.6374 | 591.3 | 319 (1995) | 0.8460 | 269.9 | 441 (1994) | 0.1170 | 51.6 | 913 |
| .. | | | | | | | | | | |
| 2089 | 1,235 (2086) | 0.1260 | 155.6 | 659 (2085) | 0.8510 | 560.6 | 1,563 (2084) | 0.1170 | 182.9 | 899 |

We also applied the exponential diffusion model (Dennis et al. 1991) to the same four time series to estimate extinction likelihoods because that is the method Waples et al. (1991) used when Snake River fall chinook were first listed.

Waples et al. (1991) used running averages with the exponential diffusion model; we used the actual escapements. Running the exponential diffusion model provides a comparison to the results of the bootstrap method and creates a link to earlier evaluations of the extinction risk that Snake River fall chinook salmon face.

The outlook for the Snake River fall chinook salmon population using escapement data truncated in 1990 is very pessimistic using either the bootstrap method (Table 10 and Figures 7-11) or the exponential diffusion model approach (Table 11). The results from the bootstrap analysis estimates that the probability of extinction is 97.0% or 98.3% (depending if the 1975-1990 or 1980-1990 data set is used, respectively) if extinction is defined as 1 fish. If extinction is defined as 30 fish (see Crammer and Neeley; 1993 for an explanation of the rational of this value) then all simulations using the data through 1990 resulted in the abundance falling below the extinction criteria. Using the exponential diffusion model with data only through 1990, the probability of the population abundance falling below extinction levels of 1 or 30 always exceeded a probability of 99%.

However, if the 1991 through 1994 escapement data is included in the analysis, the outlook for the Snake River fall chinook salmon population is substantially more optimistic. In the bootstrap analysis, none of the simulations resulted in population abundances approaching 1 fish at the end of 96 years. In fact, the probability of reducing the population to 30 fish or less was 0.3%, 5.0%, and 4.4% for the 1980-1994 data series, the 1975-1994 data series, and the weighted analysis using the 1975-1994 data series; respectively. None of these probabilities meet the criteria for an endangered species as specified by Thompson (1991). In fact, there is less than an 8% chance of the population being fewer than 300 fish in 2089, less than a 22% chance of the population being fewer than 1,000 fish in 2089, and over one-half of the simulations resulted in populations being greater than 5,000 fish in 2089. The exponential diffusion model also demonstrated markedly better forecasts using data through 1994. The probability of the escapement reaching 1 fish by 2089 decreased from over 99% to 35% using data from 1980-1994, and to 53% using data from 1975-1994. The same reduction in probability of extinction, when extinction is defined as 30 fish, was estimated to be 68% and 82%; respectively.

Table 10. Probabilities of extinction based on the bootstrap model.

| Years Used in Analysis | Probability of Extinction and Extinction Criteria | | Probability That in 2089 the Escapement Will Be Less Than | | |
|---|---|---|---|---|---|
| | 1 Fish | 30 fish | 300 fish | 1,000 fish | 5,000 fish |
| Truncated Data: | | | | | |
| 1980-1990 | 98.3% | 100.0% | 100.0% | 100.0% | 100.0% |
| 1975-1990 | 97.0% | 100.0% | 100.0% | 100.0% | 100.0% |
| Data: | | | | | |
| 1980-1994 | 0.0% | 0.3% | 0.1% | 1.1% | 5.6% |
| 1975-1994 | 0.0% | 5.0% | 7.3% | 18.9% | 44.8% |
| Weighted Recent | | | | | |
| 1975-1994 (W) | 0.0% | 4.4% | 7.5% | 21.8% | 48.8% |

Table 11. Probabilities of extinction based on the diffusion model.

| Years Used in Analysis | Mean | Variance | Probability of Extinction and Extinction Criteria | |
|---|---|---|---|---|
| | | | 1 Fish | 30 fish |
| Truncated Data | | | | |
| 1980-1990 | -0.15932 | 0.30644 | 99.34% | 99.97% |
| 1975-1990 | -0.15944 | 0.24285 | 99.65% | 99.65% |
| Recent Data: | | | | |
| 1980-1994 | -0.00135 | 0.42883 | 35.05% | 68.17% |
| 1975-1994 | -0.04094 | 0.35128 | 53.16% | 82.37% |

Figure 7. Cumulative Probability of Achieving a Given Extinction Level Using 1980 - 1990 Data

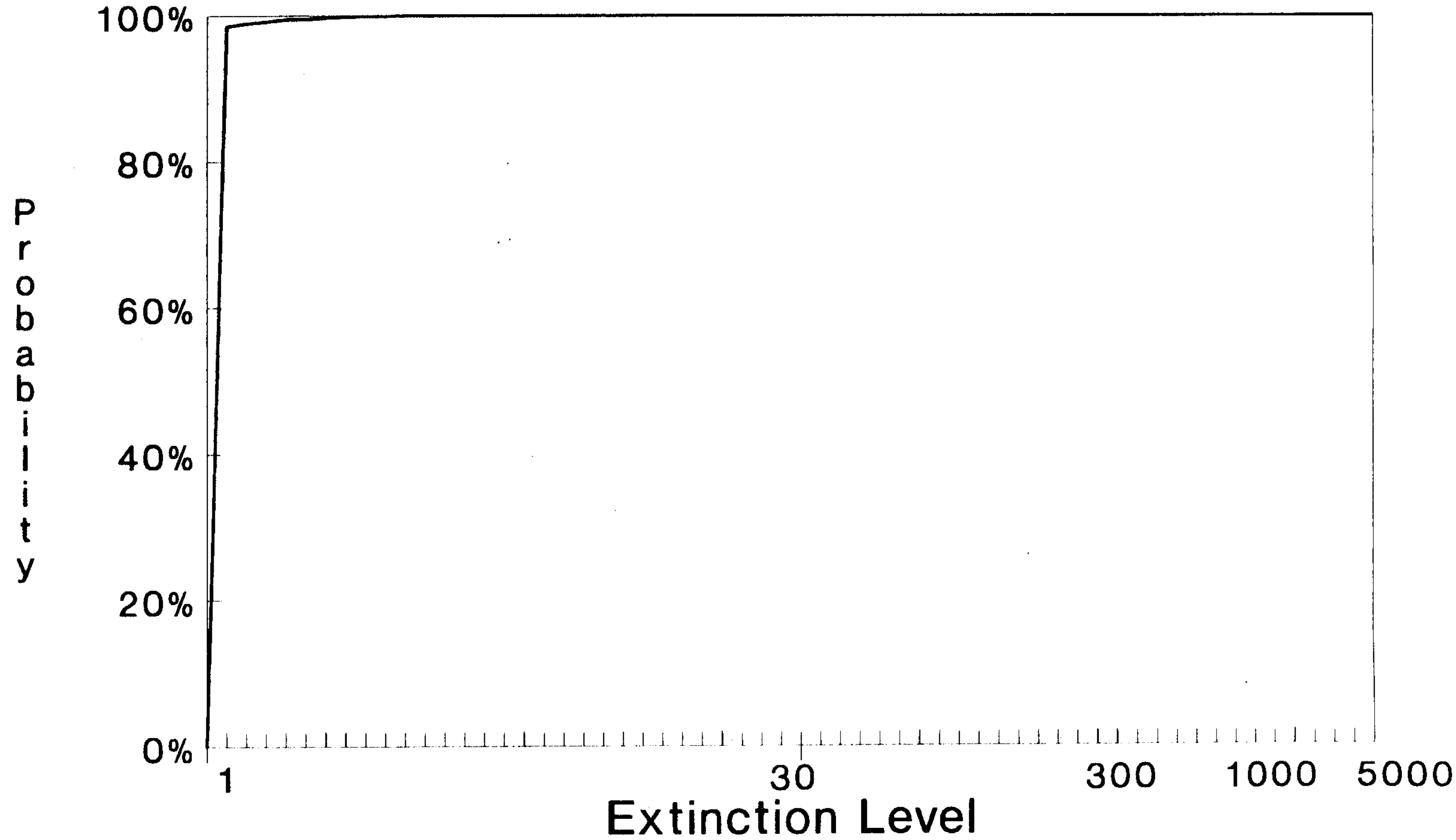


Figure 8. Cumulative Probability of
Achieving a Given Extinction Level
Using 1975 - 1990 Data

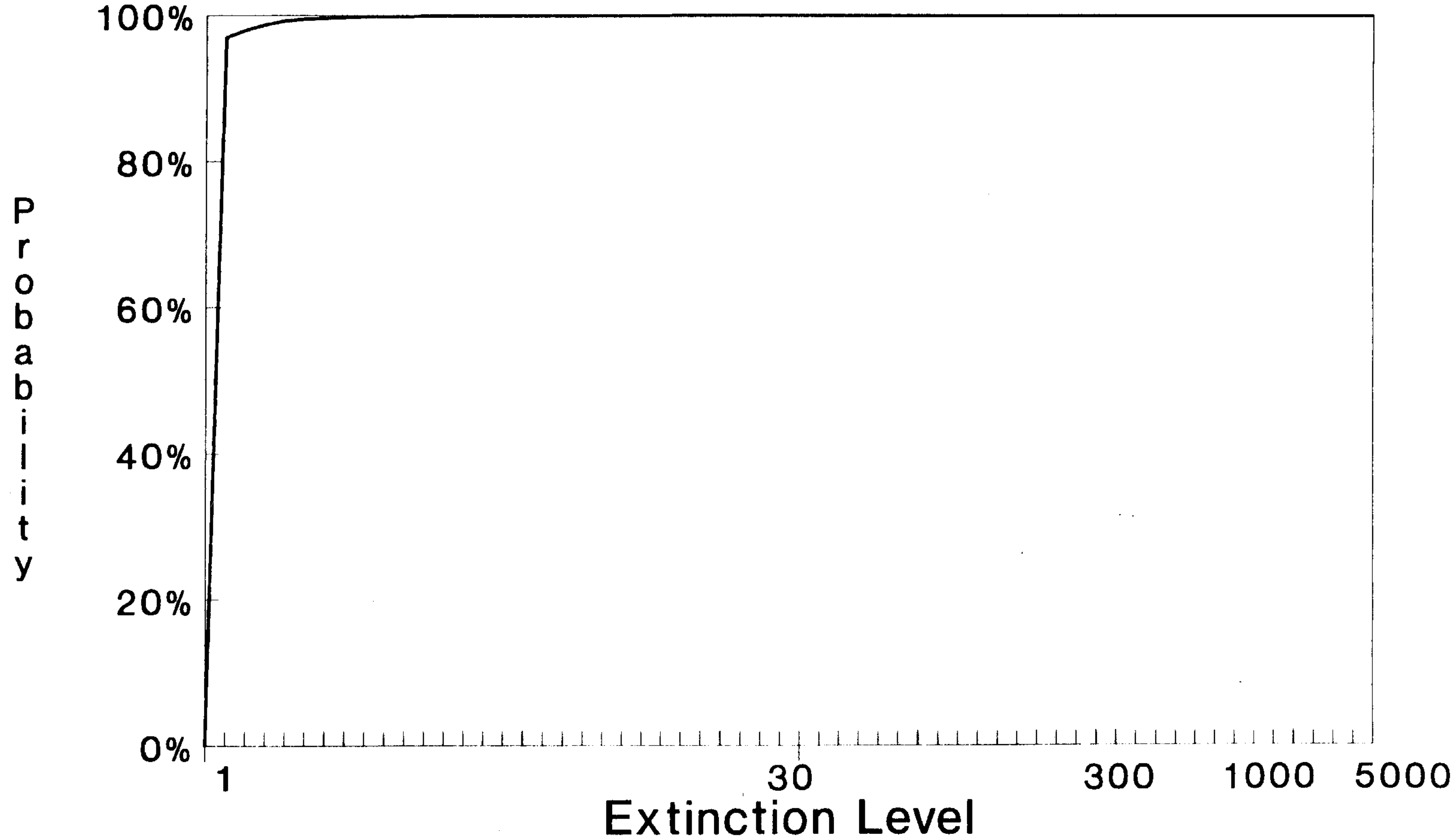


Figure 9. Cumulative Probability of
Achieving a Given Extinction Level
Using 1980 - 1994 Data

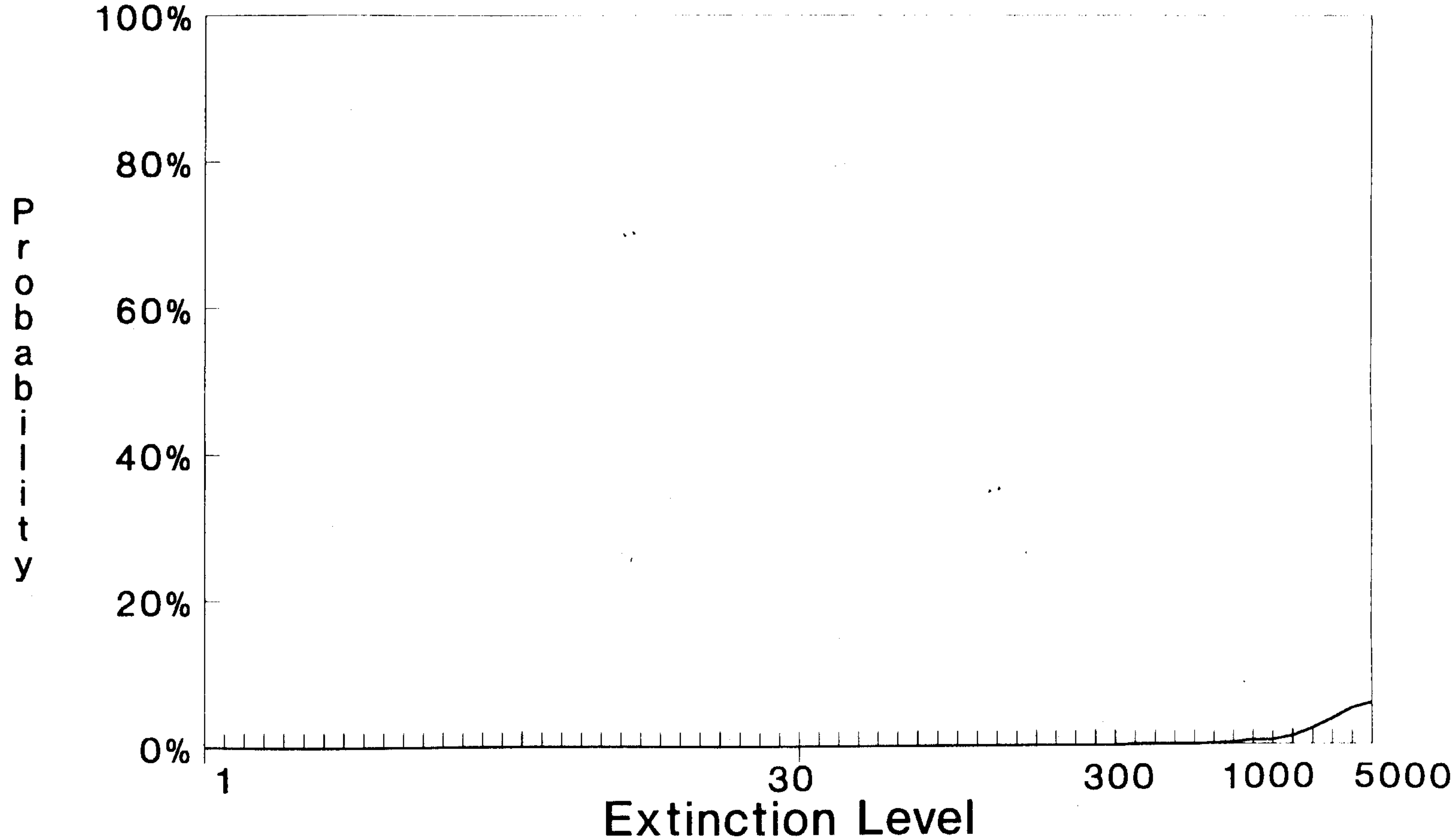


Figure 10. Cumulative Probability of Achieving a Given Extinction Level Using 1975 - 1994 Data

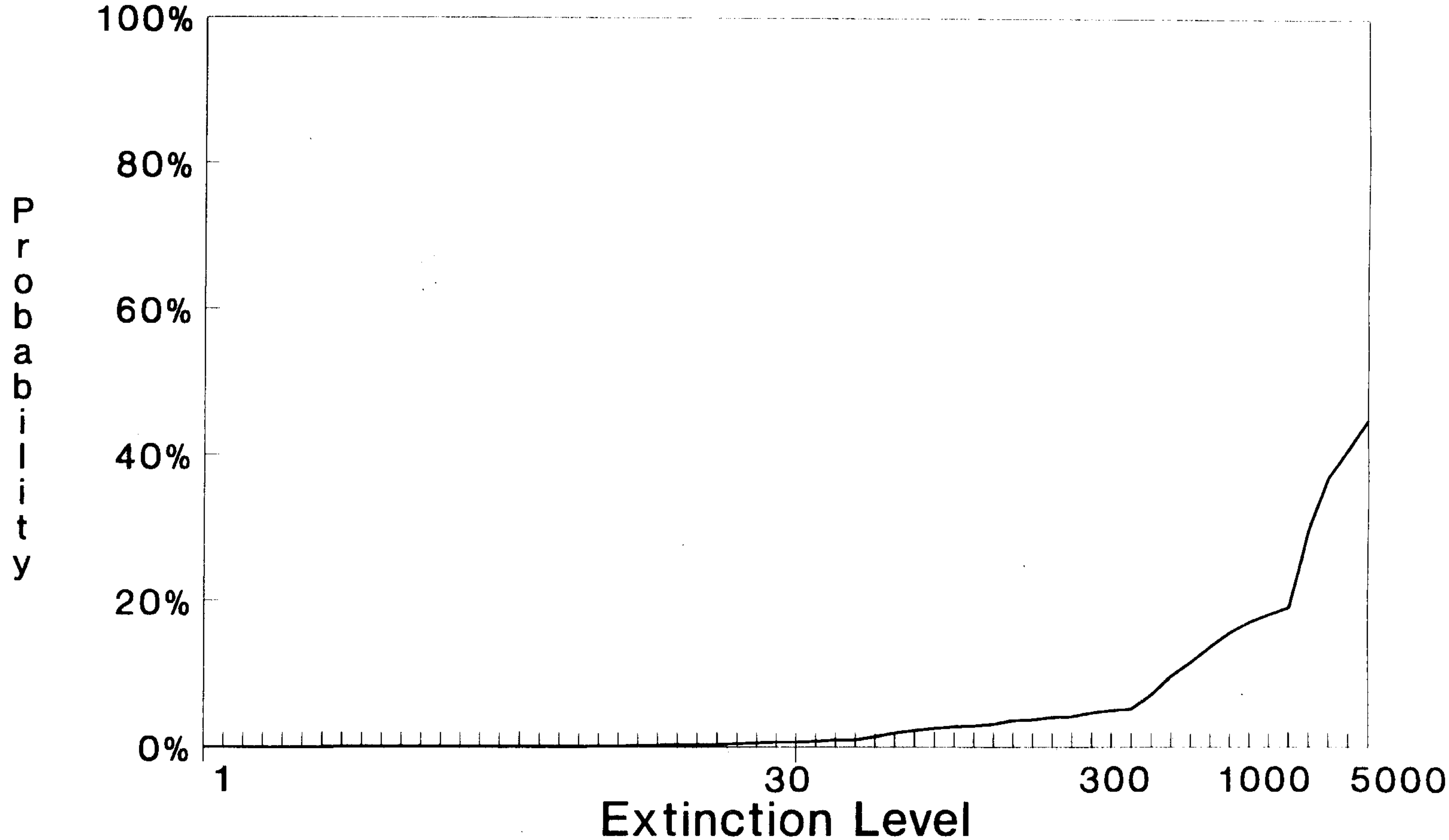
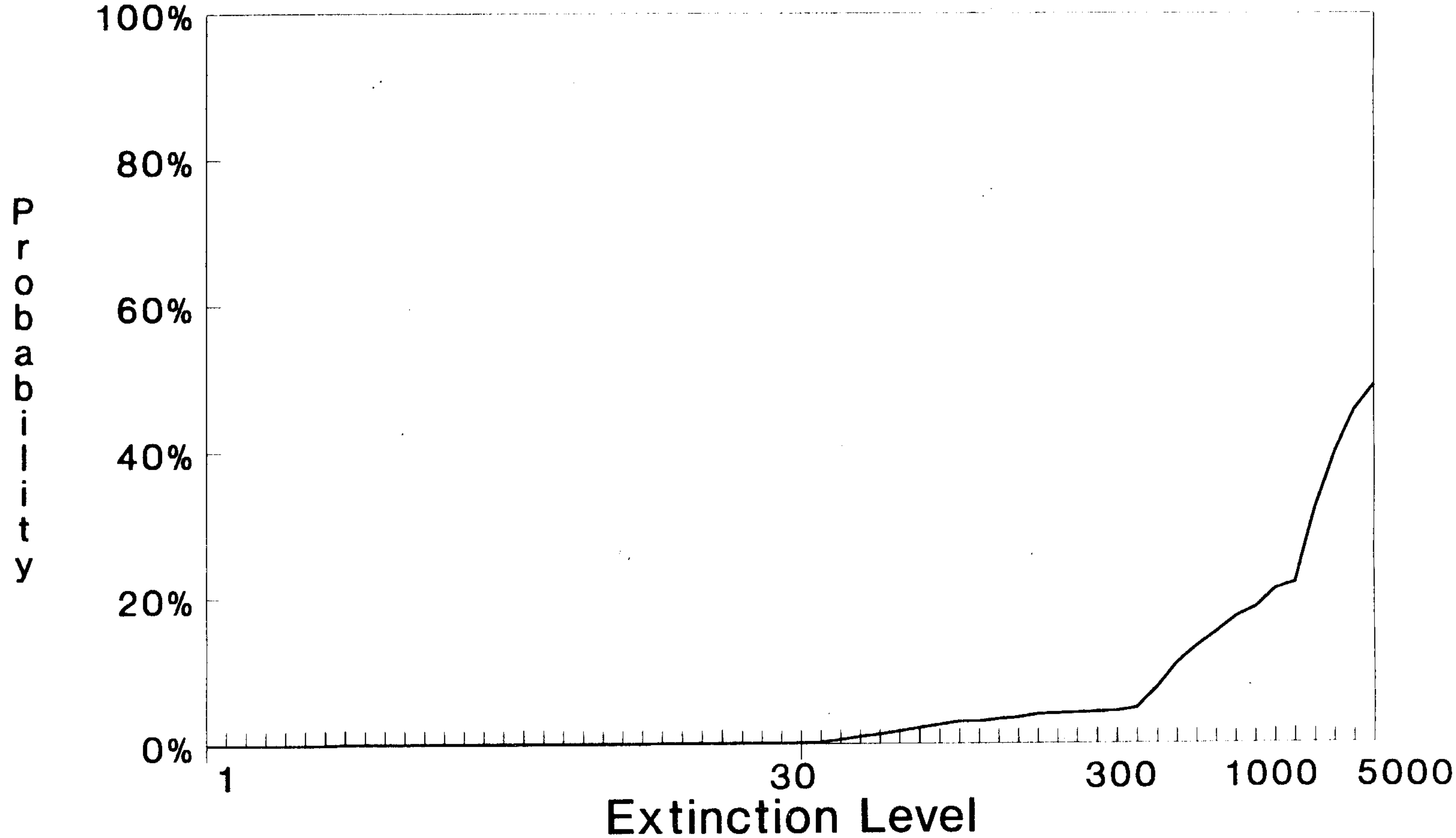


Figure 11. Cumulative Probability of Achieving a Given Extinction Level Using Weighted 1975 - 1994 Data



The addition of the 1991-1994 escapements considerably improves the assessment of the status of the Snake River fall chinook salmon stock. The 1993 escapement of 742 chinook salmon was the largest since 1975 and the 1991-1994 4-year average escapement of 512 fish was the largest 4-year average since 1977-1980. These recent large escapements, compared to the previous 10 years, are evidence that the trends in stock abundance are not nearly as bleak as previously thought. **These data do not support changing the status of Snake River fall chinook from threatened status to endangered.**

### PROBABILITY OF PERSISTENCE WITH RESPECT TO SURVIVAL

The Biological Requirements Work Group (BRWG) formed as a result of the *IDFG v NMFS* litigation settlement negotiations has been modeling Snake River fall chinook under various alternative hydro management scenarios. The State and Tribal Fishery Agencies Analytic Team (STFA), a component of the BRWG, submitted a report entitled: *Preliminary Summary of Fall Chinook Model Results for 1995 Biological Opinion* to NMFS on February 10, 1995, which provides modeling results obtained as of that date (STFA 1995). These results include estimates of the probability of persistence of Snake River fall chinook with respect to survival. The BRWG defined 300 spawners as a critical minimum escapement level for Snake River fall chinook. The STFA identified 70% as a 24 year or short-term probability level and 90% as a 100 year or long-term probability level that is equivalent to the historic probabilities used in the spring/summer chinook assessment; these values provide useful benchmarks in understanding STFA fall chinook modeling results.

The STFA estimated that the proportion of yearly escapements at or above 300 for a 24 year period was 0.38 and 0.39 with depensation and without depensation; respectively, based upon recent runs and recent hydro management conditions (BY 80-88). The STFA estimated that the proportion of yearly escapements at or above 300 for a 100 year period was 0.09 with or without depensation based on recent runs and recent hydro management conditions (BY 80-88). In other words, the proportions of Snake River fall chinook escapements exceeding the threshold value of 300 is projected to be under 40% in the short-term and under 10% in long-term if hydro management conditions remained as they were during the 1980s. These short-term and long-term probabilities are substantially less than the 70% and 90% STFA suggested benchmark levels, indicating that the stock was in jeopardy in the 1980s and would remain in jeopardy under these 1980 type hydro management conditions.

The STFA conducted similar modeling for Snake River fall chinook for a variety of other hydro system management scenarios under discussion in the *IDFG v NMFS* litigation settlement negotiations because management of the hydro system is currently being altered to benefit listed salmon species and clearly, the hydro system will not be allowed to continue to operate under the 1980-1988 base level conditions. The hydro system management scenario, as outlined in the 1994-1998 biological opinion, was used as one of the hydro system management scenarios. Depending upon depensation and a variety of assumptions concerning transport benefits and predator control effectiveness, the STFA estimated that the proportion of yearly escapements at or above 300 for a 24 year period ranged from 0.44 to 0.95 based on the 1994-1998 hydro biological opinion with 4 of the 8 (50%) model cases exceeding the short term benchmark level of 70%. Comparative probabilities for these 8 model runs over a 100 year period resulted in probabilities ranging from 0.11 to 0.96 with 2 of the 8 (25%) model cases exceeding the long term benchmark of 90%. This indicates that the probabilities of the Snake River fall chinook run having escapements in excess of 300 fish is considerably higher than was the case based on recent years; and, the level of jeopardy is reduced over the recent year model runs.

Assuming that reasonable and prudent alternatives are implemented to benefit listed salmon under the final biological opinion for the hydro-system, which will be issued as a result of the *IDFG v. NMFS* judgement, the probabilities of Snake River fall chinook escapements exceeding 300 fish will increase over the levels modeled with the original 1994-1998 biological opinion.

Indeed, when the STFA used hydro management options as defined under the Detailed Fishery Operating Plan (DFOP 1993) with 16 options under a variety of assumptions concerning depensation, transport benefits, and predator control effectiveness, the STFA estimated that the proportion of yearly escapements at or above 300 for a 24 year period was always 1.00 (always exceeded the benchmark level of 70%) and the proportion of yearly escapements at or above 300 for a 100 year period was also always 1.00 (always exceeded the benchmark level of 90%).

It is uncertain exactly how the hydro system will be managed in coming years, but it is likely that alternatives will be implemented that will increase the probability that escapements will exceed 300 fish. Hence, Snake River fall chinook are in less jeopardy now than was the case at the time of listing (the model results associated with recent BY 80-88). **The STFA model results do not support changing the status of Snake River fall chinook from threatened to endangered. The status of Snake River fall chinook is projected to improve over conditions in place at the time of**

**listing because of altered and improved hydro system management.**

## SPAWNER-RECRUIT RELATIONSHIP

Two spawner-recruit relationships were developed for the Snake River fall chinook salmon stock. The first relationship was developed using only natural adult escapements estimated to pass over Lower Granite Dam and the second relationship was developed using all adults counted over Lower Granite Dam. Escapement data used is provided in Table 3 (column 1 for naturals and column 6 for the total escapements). Estimates used to apportion escapements by age were taken from Roler (1994) for the 1975-1993 escapements and the 1983-93 average was used for the 1994 escapement.

Total returns (recruits) were calculated in adult equivalents (AEQ) for both catches and escapements. Returns in the escapement were calculated back to the river mouth by dam conversion rates included from the CTC chinook model IDL file which agree favorably with those conversion rates documented in NMFS (1994). Catches were calculated by exploitation rate analysis (ER) provided in the Pacific Salmon Commission chinook model (CTC 1994) for ocean and terminal catches. The Pacific Salmon Commission chinook (PSC-C) model does not include in-river test fish catches or some subsistence and ceremonial catches. Consequently, 30% was added to in-river catches provided in the PSC-C model to account for these catches. The PSC-C model exploitation rates are based upon coded wire tag analysis, out-putting total ER, ocean ER, and terminal ER. Total AEQ return is calculated from ESC/1-ER. Consequently, total returns were calculated as escapement to the river mouth plus terminal catches plus ocean catches, with both terminal and ocean catches adjusted to AEQs. Simple Ricker spawner-recruit relationships were fitted to the paired sets of spawners and total returns.

The estimated average AEQ return for the 1975-1989 brood years was 2,949 fish, composed of an escapement to the river mouth of 1,573 fish, an ocean AEQ catch mortality of 849 fish, and an in-river AEQ catch mortality of 527 fish (Table 12). Parent year escapements averaged 485 natural spawners. Ocean mortality averaged 29% and in-river mortality (from fishing and dams) averaged 56% of the total AEQ return and averaged 78% of the return to the river mouth. Return per spawner averaged 6.7, which is high for a population with high out-migrant mortality (i.e., even with 91% to 96% downstream mortality, an average of almost seven fish survived to die from fisheries or dams; or, escaped to spawn). This implies that some of the non-natural spawners were at least partially successful in producing progeny.

Table 12. Natural spawner-recruit relationship statistics.

| Year | Natural Escapement | In-river AEQ Catch | Ocean AEQ Catch | Escapement to River Mouth | Total AEQ Return | Return per Spawner |
|---|---|---|---|---|---|---|
| 1975 | 1,000 | 530 | 1,158 | 1,307 | 2,995 | 3.0 |
| 1976 | 470 | 382 | 1,402 | 2,092 | 3,876 | 8.2 |
| 1977 | 600 | 315 | 1,202 | 3,075 | 4,592 | 7.7 |
| 1978 | 640 | 261 | 529 | 3,130 | 3,921 | 6.1 |
| 1979 | 500 | 232 | 746 | 2,080 | 3,058 | 6.1 |
| 1980 | 450 | 203 | 593 | 778 | 1,574 | 3.5 |
| 1981 | 340 | 705 | 776 | 1,223 | 2,705 | 8.0 |
| 1982 | 720 | 465 | 458 | 691 | 1,614 | 2.2 |
| 1983 | 428 | 1,332 | 1,766 | 2,273 | 5,371 | 12.5 |
| 1984 | 324 | 987 | 1,069 | 1,494 | 3,550 | 11.0 |
| 1985 | 438 | 825 | 801 | 1,090 | 2,716 | 6.2 |
| 1986 | 449 | 407 | 640 | 561 | 1,608 | 3.6 |
| 1987 | 253 | 715 | 396 | 1,032 | 2,143 | 8.5 |
| 1988 | 368 | 250 | 485 | 1,399 | 2,133 | 5.8 |
| 1989 | 295 | 290 | 715 | 1,370 | 2,375 | 8.1 |
| 1990 | 78 | 313 | 403 | 872 | 1,588 | 20.4 |
| Averages | 485 | 527 | 849 | 1,573 | 2,949 | 6.7 |

The return per spawner for the 1975-1989 broods, when all spawners over Lower Granite Dam are included, was estimated to average 5.0 (Table 13).

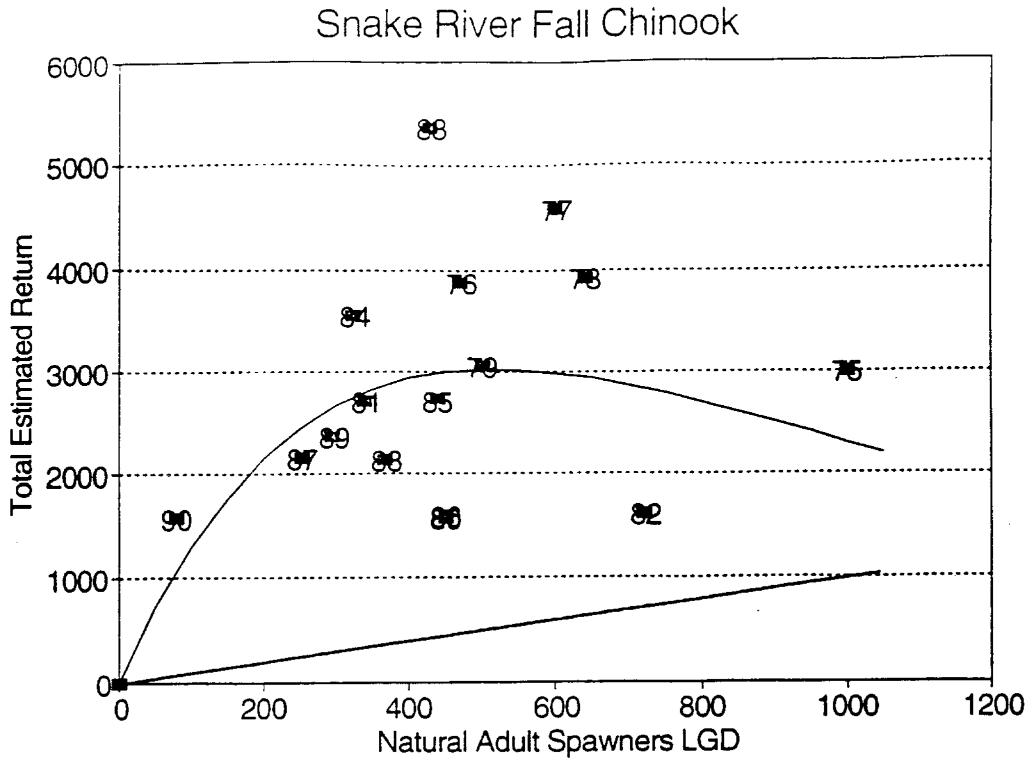
The estimated returns plotted against natural spawners shows a wide fan-shaped pattern (Figure 12). There is little evidence of density dependence as the largest escapement (1,000 spawners) produced an estimated three recruits per spawner. The estimated returns plotted against all Lower Granite Dam spawners is similarly shaped. In both spawner-recruit relationships, the estimated curve is very flat and similar levels of returns are predicted to result from various spawning levels. Morishima (1994) indicates this is typical (from simulation studies) of extreme downstream mortality. It is possible that it is a product of errors in age composition and catches. There are no data points below the replacement line in either of the two spawner-recruit relationships. If recent escapements were on the right hand side of the spawner recruit relationship where density dependence was operating, data points below replacement would be expected, particularly given the level of downstream mortality that occurs.

If the data are accurate, the estimated number of parents needed to produce a maximum sustained yield return is 440 natural adults or 472 total spawners counted over Lower Granite Dam. Another way to determine an appropriate escapement goal (other than an MSY escapement) would be to choose an escapement level that maximizes returns. The number of spawners predicted to produce maximum returns are 516 naturals or 570 total spawners over Lower Granite Dam. Recent year escapements are on the order of these estimates. The shape of the spawner-recruit curves indicates that at spawner densities observed, there does not appear to be a strong density dependent spawning or rearing limitation for Snake River fall chinook salmon. Further, recruitment is not below replacement even with the high levels of migration corridor mortality. **Based on these analysis it seems likely that escapements on the order of double the indicated MSY levels (around 1,000 adults counted over Lower Granite Dam) would produce strong returns.**

In an attempt to determine if the estimated returns were correlated with marine survival and river flows, a multiple regression with three independent variables (escapement, marine survival, and river flow) was run against the returns using both the natural escapements and the total adult escapement past Lower Granite Dam. The marine survival index was taken from CTC (1994) and was for the Salmon River chinook salmon stock, a north Oregon coast stock that has a similar ocean distribution pattern to Upper Columbia River brites and Lyons Ferry Hatchery fish. River flows were for the Snake and Columbia rivers during July and August. The multiple regressions improved the modeled fit of the

Table 13. Total spawner-recruit relationship statistics.

| Year | Natural Escapement | In-river AEQ Catch | Ocean AEQ Catch | Escapement to River Mouth | Total AEQ Return | Return per Spawner |
|---|---|---|---|---|---|---|
| 1975 | 1,000 | 530 | 1,158 | 1,307 | 2,995 | 3.0 |
| 1976 | 470 | 382 | 1,402 | 2,092 | 3,876 | 8.2 |
| 1977 | 600 | 315 | 1,202 | 3,075 | 4,592 | 7.7 |
| 1978 | 640 | 261 | 529 | 3,130 | 3,921 | 6.1 |
| 1979 | 500 | 232 | 746 | 2,080 | 3,058 | 6.1 |
| 1980 | 450 | 203 | 593 | 778 | 1,574 | 3.5 |
| 1981 | 340 | 705 | 776 | 1,223 | 2,705 | 8.0 |
| 1982 | 720 | 465 | 458 | 691 | 1,614 | 2.2 |
| 1983 | 540 | 1,332 | 1,766 | 2,273 | 5,371 | 9.9 |
| 1984 | 640 | 987 | 1,069 | 1,494 | 3,550 | 5.5 |
| 1985 | 691 | 825 | 801 | 1,090 | 2,716 | 3.9 |
| 1986 | 784 | 407 | 640 | 561 | 1,608 | 2.1 |
| 1987 | 951 | 715 | 396 | 1,032 | 2,143 | 2.3 |
| 1988 | 627 | 250 | 485 | 1,399 | 2,133 | 3.4 |
| 1989 | 706 | 290 | 715 | 1,370 | 2,375 | 3.4 |
| 1990 | 335 | 313 | 403 | 872 | 1,588 | 4.7 |
| Averages | 644 | 527 | 849 | 1,573 | 2,949 | 5.0 |



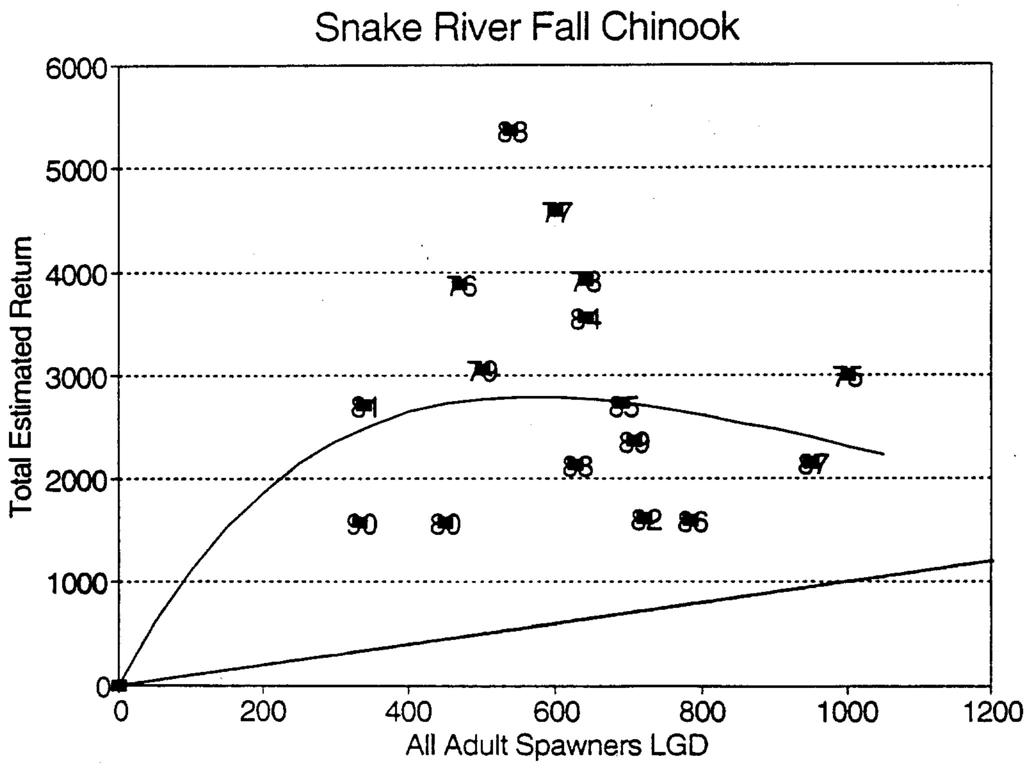




Figure 12. Estimated total returns in adult equivalents versus parent year spawners for escapement of natural (A) and all (B) adult chinook salmon spawners past Lower Granite Dam.

spawner-recruit relationships somewhat, indicating that even with confounding errors, marine survival (surrogate = Salmon River chinook marine survivals) and river flows were affecting recruitment.

Residuals for the second spawner-recruit relationship (all adults counted over Lower Granite Dam) were plotted (Figure 13). The residuals are ordered and correlate somewhat with the marine survival estimates for Salmon River chinook ($R^2$ = 0.25). The residuals are positive at the beginning of the time series and negative at the end of the time series (positive meaning the returns were higher than predicted from the spawner-recruit curve).

Because of time limits due to the deadline for responding to the December 28, 1995, Federal Register, we could not expend the level of research this topic deserves; particularly with regard to residuals analysis and comparing other variables to these residuals. **We recommend that the topic be further investigated as it likely will bear fruit useful to ESA management related activities for the Snake River fall chinook population.**

## FORECASTS OF ADULT RETURNS

The primary justification NMFS uses in the Federal Register dated December 28, 1994, for changing status of Snake River fall chinook salmon from threatened to endangered status are forecasts of abundance in 1994 and 1995. Consequently it is prudent to evaluate how well prior forecasts of Snake River fall chinook have performed. The following provides such an evaluation:

| Year | Projection of Natural Escapement Over Lower Granite Dam | Actual Escapement Over Lower Granite Dam | Differences Number | Differences Percent |
|---|---|---|---|---|
| 1993 | 457 | 742 | +285 | 162% |
| 1994 | 299 | 441 | +142 | 147% |

The forecast track record for Snake River fall chinook is short in terms of duration. Both projections significantly underestimated the actual escapements past Lower Granite Dam. Use of projections that have so significantly underestimated actual escapements as the basis for changing the listing status of Snake River fall chinook is not consistent with the Endangered Species Act requirement to use the best available scientific and commercial data when making listing decisions.

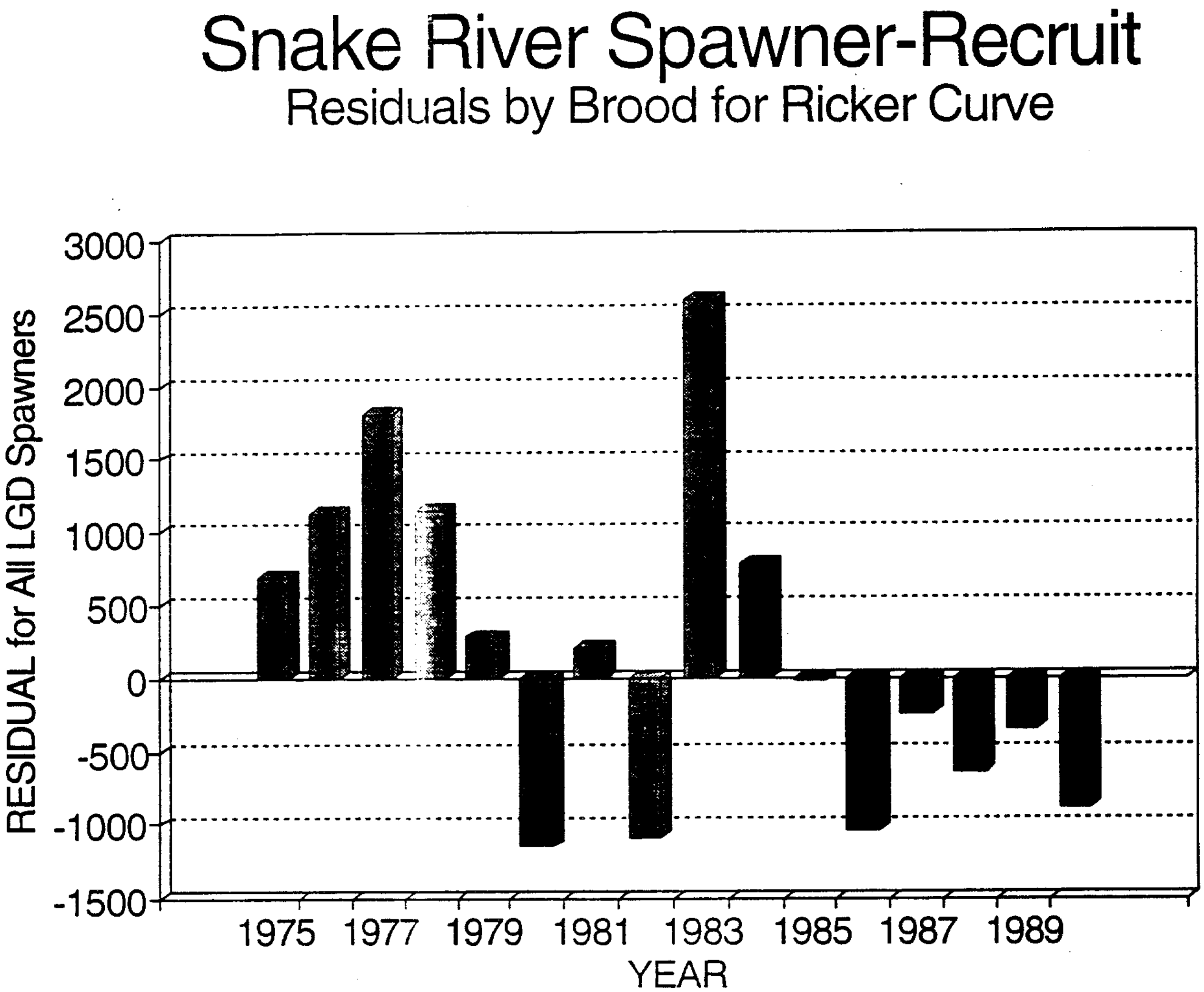



Figure 13. Residuals of predicted returns for estimated returns versus escapement of all spawners past Lower Granite Dam, 1975-90 brood years.

## HATCHERY STRAYS AND GENETIC INTEGRITY

Coded wire tag technology was developed during the late 1970s. This technology has provided fishery scientists with a tool to identify origins of returning anadromous salmonids. Releases of hatchery spawned chinook at various Columbia Basin facilities were first coded wire tagged during the late 1970s and returns of these fish during the early 1980s provided the first estimates of straying rates of these hatchery spawned fish.

Adult Snake River strays in the escapement past Lower Granite Dam were first documented in 1983 and straying of Snake River hatchery fish past this dam have occurred each year since then (Tables 3 and 4 and Figures 4 and 5). Snake River hatchery strays were estimated to represent more than 10% of the total escapement past Lower Granite Dam during 10 of the 11 years between 1983 and 1993 (Table 4) and these fish were estimated to represent more than half of the total escapement during the years 1987 (67%) and 1990 (52%).

Adult Columbia River strays in the escapement past Lower Granite Dam were first documented in 1984 and straying of Columbia River hatchery fish past this dam have occurred each year since then (Tables 3 and 4 and Figures 4 and 5). Most of the Columbia River strays were from juvenile fall chinook salmon stocked in the Umatilla River, although hatchery fish from other Columbia River system hatcheries have also strayed past Lower Granite Dam and entered the Snake River spawning grounds. Columbia River hatchery strays were estimated to represent more than 10% of the total escapement past Lower Granite Dam during 4 of the 10 years between 1984 and 1993 (Table 4) and these fish were estimated to represent more than 20% of the total escapement during the years 1989 and 1990.

The potential affect of such high hatchery stray rates on the Snake River spawning grounds, both from Snake River hatcheries and from Columbia River hatcheries was an issue of concern when Snake River fall chinook were first listed under the Endangered Species Act as a threatened species. Additionally, contamination by Columbia River hatchery fish of the brood stock used at Lyons Ferry Hatchery was a concern at the time Snake River fall chinook were listed. Waples et al. (1991) cited the proportion of Columbia River hatchery strays entering the brood stock at Lyons Ferry Hatchery as 4%, 18%, 39%, and 25% in 1987, 1988, 1989, and 1990; respectively.

In 1990, a genetic control program was implemented. "Mining" for Lyons Ferry Hatchery brood stock at Ice Harbor Dam and at Lower Granite Dam was confined to fish with coded wire tags (hatchery spawned fish). Before gametes of these fish were mixed with other gametes, their tags were read and only those fish with Lyons Ferry Hatchery codes were allowed to enter the Lyons ferry brood stock from 1990 on. Eggs and sperm taken from non-Lyons Ferry tagged fish were transferred to a downstream "mongrel" hatchery. Further, the mixed ancestry fish from the Lyons Ferry Hatchery brood stock spawned in 1989 were all marked with coded wire tags and returns from this tagged lot of fish have not been allowed into future generations of the brood stock. Also, the fish released from Lyons Ferry Hatchery and the fish released in the Umatilla River (the predominant population of Columbia River strays) since that time were all marked with coded wire tags to better enable an assessment of future straying.

An effort has been made to trap as many fish as possible at Lower Granite Dam and remove those fish with coded wire tags in an attempt to control straying of hatchery fish on the spawning grounds. This program has only been partially successful because the Lower Granite trap is not 100% efficient; and further, strays from other Columbia River hatcheries are not 100% coded wire tagged. As a result, the straying rate for Snake River hatchery fish past Lower Granite Dam reached its lowest level in 1993 (4%) while the straying rate of Columbia River hatchery fish has only been partially abated (see Mundy 1994 for a detailed description of the results of this effort). In 1993, more Columbia River hatchery strays (167 fish; 18% of the total escapement) migrated past Lower Granite Dam than did Snake River hatchery strays (43 fish; 4% of the total escapement). Further, because of the success of this program in stemming the Snake River hatchery strays, the potential effect of Columbia River hatchery strays altering the gene pool has increased (i.e. the relative contribution of Columbia River strays on the population of fall chinook spawning in the wild has increased).

Although the escapement numbers used to represent "natural" spawners in the ESU have been adjusted to account for both Columbia River and Snake River hatchery strays, the potential effect of this straying on the "gene pool" has not been adequately evaluated. Use of the escapement estimates of "natural" fish only in evaluations of escapement trends past Lower Granite Dam only partially addresses the potential problem. These estimates of the "natural" escapement are only realistic if hatchery strays are entirely unsuccessful in reproducing themselves (i.e., their fitness is zero). If fitness is anything other than zero, the effect of straying is cumulative. In other words, the proportion of "stray" genes in the population at any one time is a function of both fitness and the additive level of straying that continues to occur each year.

A simple dilution model was developed to better evaluate the effect of straying on the "natural" escapement gene pool.

The starting assumption was that no straying of Snake River hatchery fish occurred prior to 1983 and no straying of Columbia River hatchery fish occurred prior to 1984. Although these are the first years when straying was documented, it must be remembered that prior to this time, coded wire tag technology was not available to detect strays. It seems likely that strays, both from the Snake River hatchery program (Hagerman Hatchery) and from the Columbia River hatchery program (various hatcheries) likely entered the Snake River spawning grounds prior to 1983. Thus the dilution model will likely underestimate true effects. A second assumption used in the dilution model was that random mating occurred among all fish in the escapement. Annual stray rates as documented in Table 4 were used along with an assumed age composition for returns of 30% age 3, 56% age 4, and 14% age 5. Fitness values of 0.0, 0.5, and 1.0 for all hatchery strays and for just Columbia River hatchery strays were used through this time series dilution model to predict the composition of the current gene pool.

The additive effects of continued straying on the gene pool if fitness of strays is other than zero is readily apparent from this simple dilution model (Table 14 and Figure 14). If both Snake River and Columbia River hatchery strays are a concern, fitness values of 0.5 and 1.0 result in the 1994 gene pool being composed of only 24% and 10% "natural" genes; respectively. If only Columbia River hatchery strays are a concern, fitness values of 0.5 and 1.0 result in the 1993 gene pool being composed of only 78% and 62% "natural" genes; respectively. It seems unlikely that fitness of strays is zero and it seems unlikely that straying of hatchery fish above Lower Granite Dam was merely coincidental with the advent of coded wire tag technology. Consequently, it seems likely that at least some level of introgression of the gene pool called "naturals" has occurred due to straying of hatchery fish. Thus the gene pool of progeny of fish that spawn in the wild today is likely different than it was a few years ago.

A similar dilution model was developed for the Lyons Ferry Hatchery brood stock (Figure 15). Results indicate that the current brood stock is likely more similar to the prior "natural" stock than is the current population of fall chinook spawning in the wild and this is because of the efforts at the hatchery to protect the genetic integrity of the brood stock.

Although there is a clear potential for introgression of the Snake River fall chinook gene pool by Columbia River hatchery strays, the question of fitness of these strays remains somewhat open. Waples et al. (1991) provided genetic data showing the relationship of Snake River fall chinook to other Columbia River chinook populations as well

Table 14. Dilution effects on the gene pool of Snake River fall chinook salmon labeled as "natural spawners" prior to 1983 due to estimated numbers of strays entering into the escapements since 1983 under various assumptions concerning the "fitness" of the two types of strays.[1]

| | Estimated Proportion of the *Gene Pool* Composed of "Natural Spawners"[1] (heading abbreviations: (N) = "naturals; (S) = strays; F = "fitness" | | | | |
|---|---|---|---|---|---|
| | Snake River and Columbia River Strays Included in the Stray Category | | | Only Columbia R. Strays Included as "Strays" | |
| Year | F(N) = 1.0 F(S) = 0.0 | F(N) = 1.0 F(S) = 0.5 | F(N) = 1.0 F(S) = 1.0 | F(N) = 1.0 F(S) = 0.5 | F(N) = 1.0 F(S) = 1.0 |
| 1975 | 100% | 100% | 100% | 100% | 100% |
| 1976 | 100% | 100% | 100% | 100% | 100% |
| 1977 | 100% | 100% | 100% | 100% | 100% |
| 1978 | 100% | 100% | 100% | 100% | 100% |
| 1979 | 100% | 100% | 100% | 100% | 100% |
| 1980 | 100% | 100% | 100% | 100% | 100% |
| 1981 | 100% | 100% | 100% | 100% | 100% |
| 1982 | 100% | 100% | 100% | 100% | 100% |
| 1983 | 100% | 88% | 79% | 100% | 100% |
| 1984 | 100% | 67% | 51% | 100% | 99% |
| 1985 | 100% | 78% | 63% | 99% | 98% |
| 1986 | 100% | 70% | 54% | 99% | 99% |
| 1987 | 100% | 35% | 20% | 97% | 94% |
| 1988 | 100% | 54% | 34% | 95% | 90% |
| 1989 | 100% | 44% | 25% | 83% | 70% |
| 1990 | 100% | 23% | 10% | 85% | 75% |
| 1991 | 100% | 32% | 16% | 92% | 85% |
| 1992 | 100% | 44% | 24% | 91% | 85% |
| 1993 | 100% | 34% | 17% | 78% | 62% |
| 1994 | 100% | 24% | 10% | - | - |

[1] The simple dilution model used to derive these estimates assumed the gene pool was 100% "natural spawners" prior to 1983 when coded wire tag data technology first provided estimates of hatchery strays passing Lower Granite Dam. The model assumes random mating; stray rates as defined in Table 4 were used; age composition of escapements were assumed as follows: 30% age 3, 56% age 4, and 14% age 5. A fitness value of 1.0 assumes that strays reproduce as successfully as "naturals". A fitness value of 0.5 assumes that strays are only half as successful at spawning as are "naturals" and a fitness value of 0 assumes that strays are unable to successfully reproduce.

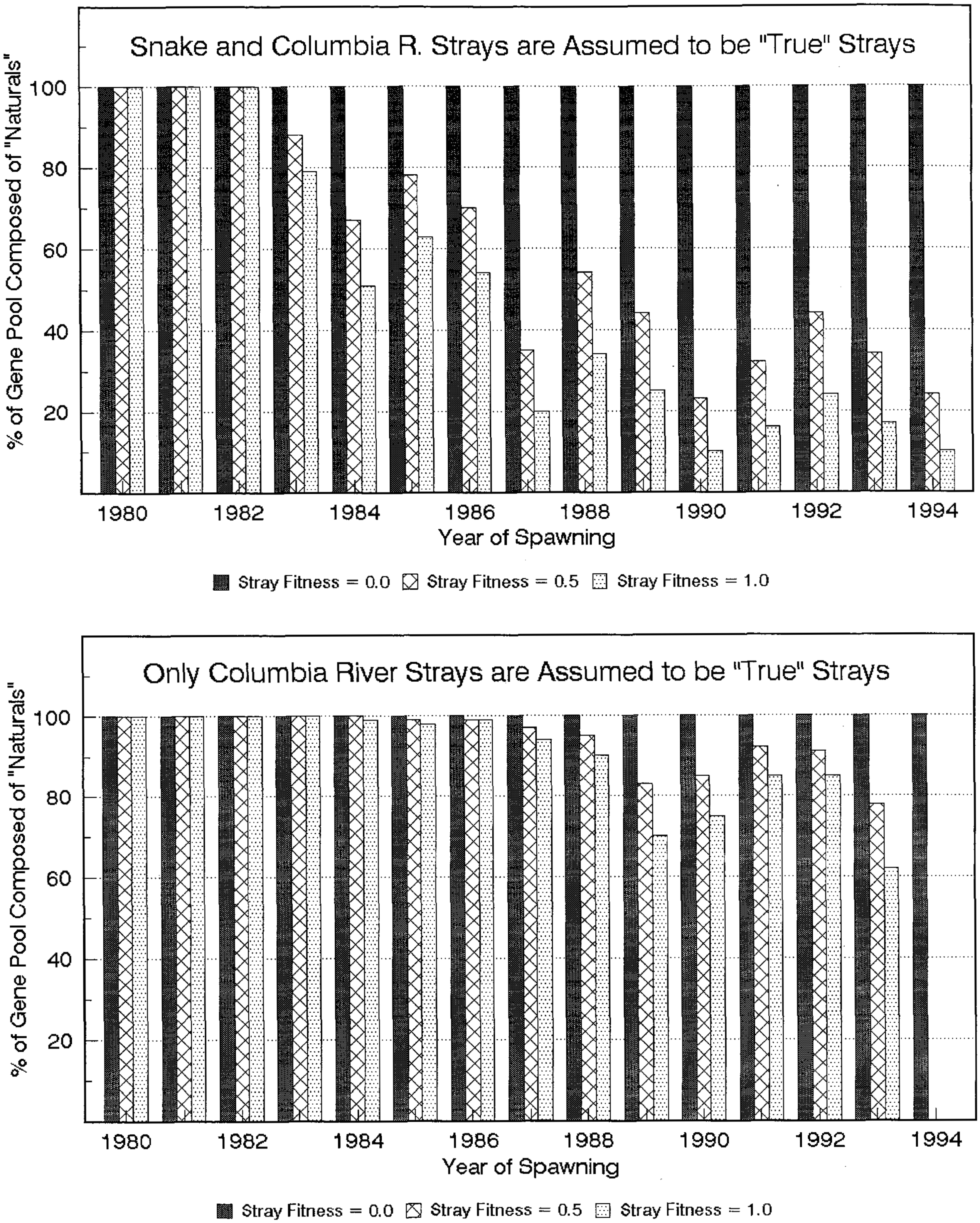
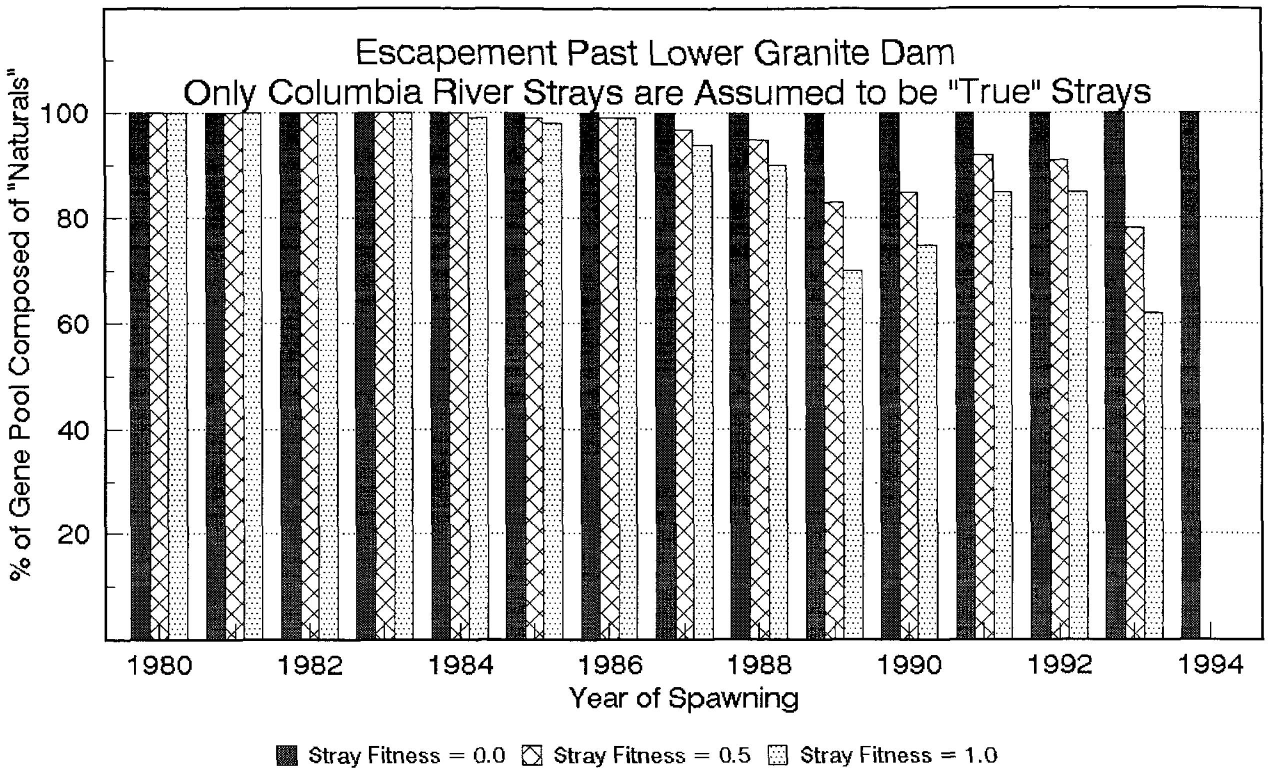



Figure 14. Composition of the gene pool of the fall chinook escapement past Lower Granite Dam based on a simple dilution model with various assumptions concerning fitness of strays.



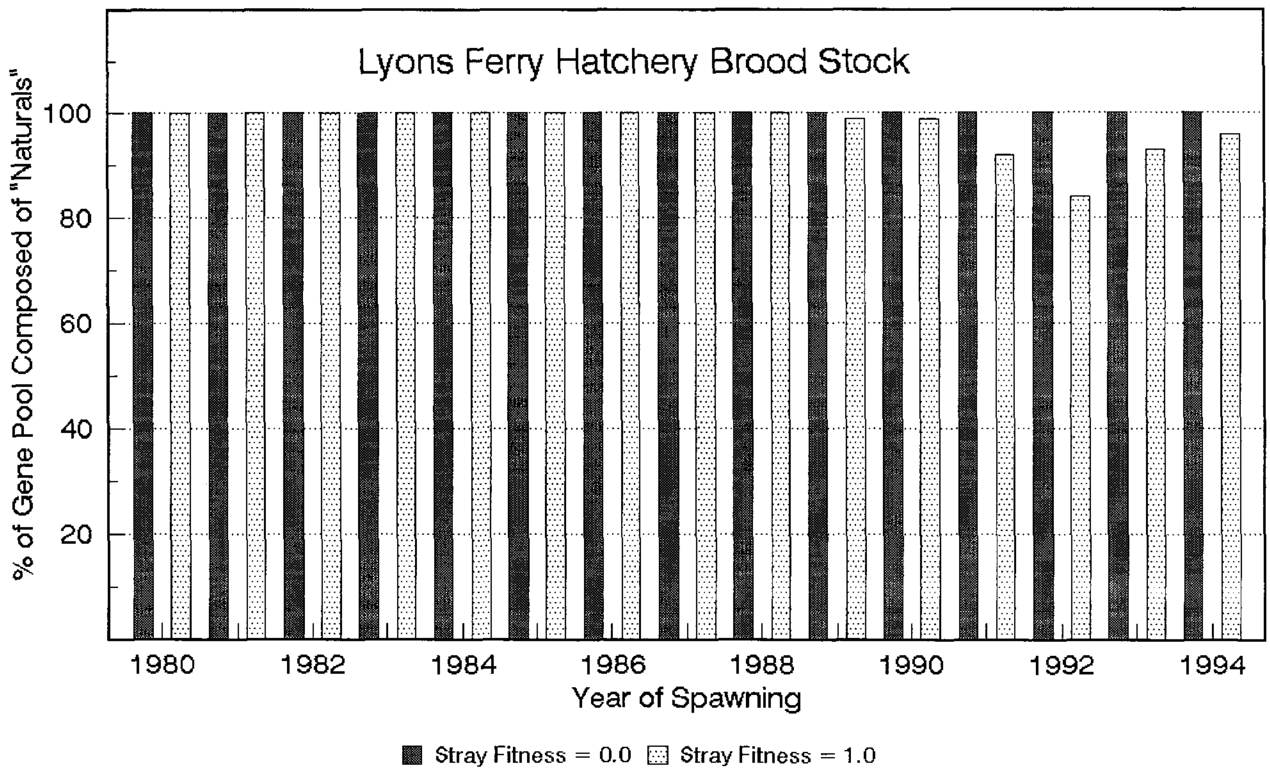




Figure 15. Composition of the gene pool of the fall chinook escapement past Lower Granite Dam and the Lyons Ferry Hatchery based on a simple dilution model with various assumptions concerning fitness of strays.

as showing how allelic frequencies of Snake River fall chinook were potentially converging with Upper Columbia River fall chinook populations.

Since the initial listing decision, fall chinook salmon spawning in the Snake River have been genetically sampled along with outmigrating juveniles and Lyons Ferry hatchery fish. Although results from much of this research have not been published and made generally available, the researchers involved with these studies have verbally told Alaska Department of Fish and Game staff that:

> Samples of fall chinook adults returning to the Snake River, including strays, have an increased genetic affinity to the Columbia River cluster of populations.
>
> Samples of juveniles collected from the Snake River cluster with the historic Snake River fall chinook group rather than with any other group.
>
> The genetic distances, albeit small, between Snake River and Columbia River fall chinook, observed by NMFS in the 1970s, generally persist through 1994.
>
> Rare genotypes endemic to the Snake River fall chinook population persist in the 1994 juvenile collection.
>
> Stray chinook from the Columbia River apparently have not shifted the frequencies of the Snake River out-migrants, nor have they swamped rare endemic genotypes.
>
> Snake River fall chinook rare genotypes have not been lost due to bottlenecking.
>
> The available genetic data indicates that the Columbia River strays have not contributed substantially, at least yet, to the Snake River gene pool.
>
> Although the Snake River fall chinook ESU is facing challenges from straying and bottlenecking, the ESU remains basically intact through 1994.
>
> Lyons Ferry Hatchery is the reserve for genotypes for the ESU and Lyons Ferry Hatchery fish should be included in the ESU.

The dilution modeling results and comments from geneticists studying potential introgression of the Snake River fall chinook salmon ESU indicate that it would be prudent to add the Lyons Ferry Hatchery brood stock into the Snake River fall chinook salmon ESU. The following factors also support the inclusion of the Lyons Ferry Hatchery brood stock.

The Lyons Ferry Hatchery brood stock offers the potential of restocking what remains of the Snake River fall chinook's natural habitat while maintaining genetic integrity. Presumably, the exclusion of the Lyons Ferry Hatchery brood stock stems from the view that the protections of the ESA should extend only to listed species in the wild, not species that have been removed from natural ecosystems. However, the habitat of the Snake River fall chinook has been drastically altered and the remaining freshwater spawning and rearing habitat is but a fraction of what was available historically. The progeny of "naturally" spawning fish are currently protected under the ESA, even though they are routinely removed from the wild and transported through the river migration corridor by truck or barge. There is no sound biological reason to exclude fish with the same genetic lineage from the protections of the Act, merely because they spawned and reared in the "unnatural" habitat of the Lyons Ferry Hatchery.

The exclusion of the Lyons Ferry Hatchery brood stock leads to an illogical result, by splitting a distinct population into a protected and an unprotected class.

The exclusion of the Lyons Ferry Hatchery brood stock leads to an illogical result, by creating a situation where members of a distinct population segment move into and out of the ESU across generations. Consequently, progeny of the distinct population segment may or may not be afforded protection under the ESA, depending upon where they reproduce.

The exclusion of the Lyons Ferry Hatchery brood stock means that the segment of the population that is most similar to the historic population segment is not protected under the ESA, while a population that may be less similar to the historic population segment is protected.

The level of genetic distinctness (genetic distance, see Waples et al. 1991) between Snake River fall chinook and Columbia River fall chinook is small, but apparently this difference is persisting in the face of substantial straying. Further, the Snake River historically provided unique chinook habitat. For these reasons, although it may be prudent to retain a distinct population segment of Snake River fall chinook salmon, the focus and intent should be that fall chinook retain an important role in the ecology of the Snake River ecosystem. The protected population should include Snake River hatchery fish and fish that spawn naturally in the Snake River.

Because the Snake River habitat has been so altered by the construction of dams, adaptive evolution of the chinook population inhabiting this area will likely take place. In that vein, the past and continued straying of Columbia River fall chinook and the mixing of these fish with the endemic Snake River fall chinook population may in the end be beneficial as the population evolves and adapts to this severely altered ecosystem.

**Although the question of changing the status of Snake River fall chinook from threatened to endangered was addressed in this document from the standpoint of the currently defined ESU, best available scientific and commercial data indicates that the ESU itself needs redefinition.** Subsequent to redefinition of the ESU, the question of whether or not the revised ESU should be included on the endangered species list; and, if so, at what level, threatened or endangered, needs to be evaluated and answered based upon best available scientific and commercial data.

## CONCLUSIONS

**The best available scientific and commercial data indicates that the change in status of the currently defined Snake River fall chinook salmon ESU from threatened to endangered is not appropriate. Status of the currently defined ESU has improved since listing and the likelihood of extinction has diminished. Further, we believe that it is the ESU itself that needs to be redefined.**

We have identified six factors we believe need to be analyzed and considered prior to any reclassification of Snake River fall chinook. Highlights of our analyses are as follows:

### 1. Escapement

The recent year average of non-hatchery spawned adult chinook passing upstream of Lower Granite Dam (1991 to 1994) is 510 fish. This is 55% higher than the 1983 to 1990 average of 330 fish. After the effect of "mining" has been accounted for, the 1991-94 average of 512 fish is 12% greater than the 1983 to 1990 average of 456 fish. By either analysis, the population has increased since first being listed as threatened.

### 2. Likelihood of Extinction

We analyzed the probability of extinction using both the original Dennis extinction model and a bootstrap model, and compared performance through 1990 and through 1994. The outlook using data through 1990 is very pessimistic for either model, with the probability of extinction being greater than 97%. The addition of data through 1994 considerably improves the assessment of the stock. Over 50% of the simulations using the bootstrap method resulted in populations greater than 5,000 fish in 100 years. The Dennis model responded similarly with the probability of extinction (extinction defined as 30 or fewer fish) dropping to 68%.

### 3. Probability of Persistence with Respect to Survival

The STFA analyzed the probability of persistence for the draft 1994-98 hydro biological opinion. Depending upon the assumptions in it, they concluded that the proportion of yearly escapements at or above 300 for a 24-year period ranged from 0.44 to 0.95. Further, the DFOP plan assembled by the States and Tribes estimated that the proportion of yearly escapements at or above 300 for a 24-year period is always 1.00. Although it is uncertain how the hydro system will be operated, it seems certain that the hydro system management, once defined, will increase the probability that escapement will exceed 300 fish.

### 4. Spawner-Recruit Relationship

A Ricker spawner-recruit relationship was derived from the data. If the data are accurate, a total of 440 "natural" adults or 472 total spawners are needed to produce maximum sustained yield under the present conditions of reduced habitat availability and quality. The number of spawners that would produce the maximum return are 516 "naturals" or 570 total spawners over Lower Granite Dam. However, given that: (1) there are measurement errors and confounding environmental influences in the database; (2) there is little evidence of density-dependent mortality shown; and, (3) the estimated return per spawner was 3:1 for the 1975 observed escapement of 1,000 spawners, we conclude that escapements on the order of double the MSY (1,000 fish) would produce strong returns. Escapements over Lower Granite Dam since 1991 average 730 adults, 54% above indicated MSY and 27% less than the 1,000 fish we believe to be an appropriate de-listing goal.

### 5. Forecasts of Adult Returns

In proposing a change in status, NMFS has used the 1994 forecast and guesses concerning the 1995 and later runs as evidence for changing the listing. Past forecasts for Lower Granite Dam escapement are only available for 1993 and 1994. The prior forecasts were substantial underestimates (62% in

1993 and 47% in 1994). The continued use of forecasts by the NMFS when they have been shown to be so significantly in error in the past, is not consistent with the ESA requirement to use the best available scientific and commercial data.

## 6. Hatchery Strays and Genetic Integrity

Hatchery strays from both the Columbia and Snake Rivers have been documented since 1983. We evaluated the effect of straying on the natural escapement gene pool. If both Snake and Columbia River hatchery strays are a concern and fitness values of 0.5 and 1.0 are used, the 1994 gene pool is composed of 24% and 10% "natural" genes, respectively. A similar analysis for the Lyons Ferry Hatchery brood stock indicates that the current brood stock is likely more similar to the pre-dam "natural" stock than is the current population that is spawning in the wild. We also conclude that because the habitat has been so altered by hydro development, adaptive evolution of the chinook population inhabiting this area will likely take place. We believe that it is the ESU itself that needs to be redefined.

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